PROJECT REPORT

A COMPARATIVE STUDY ON THE INFLUENCE OF RECORDING OPTIONS ON SPEECH ANALYSIS

ARF Ref No: 67/2016-17

All India Institute of Speech and Hearing

Manasagangothri, Mysuru - 570006

November 2020

A Comparative Study on the Influence of Recording Options on Speech Analysis

Project under AIISH Research Fund (ARF)

Year: 2016-17

Ref: SH/CDN/ARF/67/2016-17

Total grants: Rs 4,93,000/-

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Acknowledgments

The investigators would like to acknowledge the Director, All India Institute of Speech and Hearing for being pivotal in granting AIISH Research fund for the project. We would like to acknowledge the HOD, Department of Speech Language Sciences & Department of Electronics for allowing us to use the resources from the department for testing. We would like to extend our sincere thanks to Sri. Ravi S, System Engineer and all other staff of Department of Electronics for their technical support. We also would like to extend our appreciation to the accounts section for providing support in maintaining the accounts. Our heartfelt gratitude also extends to all the participants involved in this study for their kind cooperation.

Contents

Abstract

Recording of speech samples is the first and important step in assessment, diagnosis, monitoring of progress in rehabilitation and research in the field of communication disorders. A reliable, user friendly, widely available and cost effective recording protocol is essential to achieve the required recording quality for accurate analysis of the speech samples. An evaluation of the reliability across recording methods requires consideration of hardware, protocols and acoustic analysis to determine the closeness of recorded speech sample to original one. Factors affecting the quality of recording were investigated in the past by several researchers. The outcome of one of these suggests that, highest quality recording would be made using a stand-alone digital recorder with high quality microphone in a sound treated room. This setup is quite expensive, unaffordable and not readily available for most of the researchers and clinicians. Hence, there is a need to find an alternative, widely available and cost effective configuration with optimal quality recording. This project aims to identify and validate a cost effective combination of microphone, digitizing system (sound card), processing system (laptop) etc. which will result in optimal quality recording. The effective combination would be arrived through investigation of the influence of each of the hardware components and associated factors by comparing the spectral, temporal and spectro-temporal parameters of the recorded speech with the speech recorded by a benchmark system. The benchmark system for comparison would be a precision recording system connected with a higher end condenser microphone. Parameters considered in the study include the fundamental frequency, first and second formant frequencies, voice onset time (VOT), closure duration (CD), transition duration (TD) and spectral tilt. Voiced and unvoiced stop consonants paired with vowel /a/ were used as the speech syllables. Ten participants (five males and five females) in the age range of 21-36 were instructed to utter the syllables with an appropriate loudness in a natural manner. The uttered syllables were recorded by the benchmark system and all the sixty laptop microphone combinations considered for the study. The optimal configuration identified in comparison with the

benchmark system was validated by another set of six participants. The study succeeded in identifying a validated cost effective laptop microphone combination for recording speech samples with optimum quality.

CHAPTER 1

Introduction

Human voice production is an intricate and highly coordinated activity, the result of which contributes to the strings of sounds in the form of words or sentences to convey ideas and thoughts. Every speech sound that is produced through this intricate process is thought to comprise a set of features in the temporal and spectral domain. These set of parameters evolve from certain factors such as tongue position, lip shape, intra oral breath pressure, context, and timing of utterances etc., resulting in the definite acoustic patterns for specific speech sounds. Quantitative estimation of the acoustic patterns of speech sounds is gaining importance in the clinical setting as it helps efficient correlation of the measures with perceptual observations along with instrumental evaluations (Vogel & Morgan, 2009). Such a correlation would assist in effectively documenting assessment or treatment outcomes, thus making acoustic analysis of speech essential. In its simplest form, basic acoustic analysis would require a recording system along with any analyses software such as Praat (Boersma & Weinik, 2001). Recording of speech samples is the first and important step in assessment, diagnosis, monitoring of progress in rehabilitation and research in the field of communication disorders. However, determining an appropriate hardware or software configuration for speech recording is often a complex task because there could be a number of influential variables affecting the process. A reliable, user friendly, widely available and cost effective recording system is essential for achieving the desired objectives of all these activities. An evaluation of the reliability across recording methods requires consideration of hardware, recording protocols and acoustic analysis to determine the closeness of recorded speech sample to the original one.

Factors affecting the quality of recording were investigated in the past by several researchers. The outcome of one of these suggests that, highest quality recording would be made using a stand-alone digital recorder with high quality microphone in a sound treated room. This setup is quite expensive, unaffordable and not readily available for most of the researchers and clinicians. A fairly good quality microphone is the most inevitable requirement for any speech recording. There are plenty of feature variations available in commercial microphones as well as in specialized task-specific microphones. Basically two types of microphones are used widely for recording of speech. These include the dynamic and the condenser microphones. The dynamic microphones are those that do not require any external power supply making them appropriate for a number of field recordings. The dynamic microphone consists of a diaphragm attached with a wired coil that is suspended within a strong magnetic field. As a speech wave traverses, it hits the diaphragm and the coil attached to the diaphragm is displaced in relation to the amplitude of the speech wave against the magnetic flux which is created by the permanent magnet. However, these microphones do not respond to sharp, short, transient syllables because the mass of the coil and the diaphragm are larger compared to the pressure changes of the incident sound. Hence these microphones may not be able to detect minute changes in the vocal intensity (Plichta, 2002). A condenser microphone consists of a condenser capsule that consist of a thin membrane/ diaphragm which is located proximal to a solid metal plate. When sound waves hit the diaphragm, it moves back and forth in relation to the metal plate. This results in a change in the distance between the plates of a capacitor causing changes in capacitance. These microphones thus, give very high quality recording because of very thin diaphragm that gives most accurate response. However, condenser microphones are not suitable for field recording as they require a constant external power source (Plichta, 2002).

For optimal and good quality recordings, the recording environment also plays a role in addition to the type of microphone used. Ideally, recordings should be carried out in sound treated rooms. However, in the absence of such a set up, one can opt for a surrounding with very minimal external noise (Plichta, 2002). In addition, a suitable recording device is also required for establishing good quality recordings. A highest quality recording could be made using a stand-alone digital recorder with high quality microphone in a sound treated room. Traditionally, analog recording devices such as tape recorders were used widely. However, performing analyses on the recordings from such analog devices was difficult as these recordings need to be digitized for any analysis. This gave way for digital recorders that are used widely in recent times. Digital recording methods constitute analog-to-digital conversion at its heart. Analog-to-digital conversion of the input signal refers to the process in which an analog sound signal is converted into a digital form in order to make it compatible for PC based analyses further. The input analog signal is sampled at very short time intervals and then represented in binary number system. The signal is then quantized and stored in more accessible digitized form (Plichta, 2002). This makes it easier to be stored, accessed and processed further, thus enabling acoustic analyses effortless. Plichta (2002) concluded that acoustic analysis of speech could be improvised with the right choice of acquisition and processing methods and tools. He also added that it could be possible to attain the best recordings in the less sophisticated and inexpensive methods.

Vogel et al. (2015) compared the speech recorded through modern devices such as smart phones, landlines, laptops, and hard disc recorders. Comparison was based on the acoustic analysis carried out using Praat and the Computerized Speech Laboratory's Multi-Dimensional Voice Program (MDVP). The parameters evaluated were mean F0, highest F0, lowest F0, F0 range, SD F0, percent jitter (% Jitt), percent shimmer (% Shim), noise-to-harmonic ratio (NHR), voice turbulence index, and soft phonation index (SPI). The results showed that none of the methods of acquisition for capturing voice and speech could provide statistically equivalent values compared to the benchmark system (i.e., a high-quality recorder coupled with a condenser microphone). Speech and voice parameters of samples recorded through personal computer was compared with hard disk and sold state recorders by Vogel and Maruff (2008). They could not find any significant differences between the two. Though, not of high quality, laptops are preferred by most of the clinicians and researchers because of the medium budget. Vogel and Morgan (2009) stated that the quality of recording in laptops is medium, but may be appropriate for some acoustic measures except measures of perturbation. Laptops are available in different hardware/ software combinations and hence it is difficult for a clinician or researcher to select the appropriate one. Hence, it would be appropriate if an optimal laptop configuration is recommended for acquisition of speech samples.

Many researchers have identified and compared the factors affecting the quality of sound recording, but none of these researchers have arrived at an optimal laptop configuration, considering the hardware components and processing features, which would result in a quality recording. Non-availability of widely available and cost effective recording configurations restricts opportunities for acoustic analysis in multi-site research studies (Vogel et al., 2015). Hence, there is a need to find out an optimal cost effective configuration for recording of speech samples. Thus, the aim of the present study was to evolve a cost effective configuration of laptop for optimal recording of speech samples for speech analysis.

The study was conducted with the following objectives:

- Investigate the effect of different laptop configurations, sound cards and microphones on the fundamental frequency, formant frequencies, durations and spectral tilt of the speech samples recorded from the participants in comparison with that of the same samples recorded by a benchmark system.
- Compare and identify the most significant factor/ factors individually and in combination.
- Investigate the effect of gender on the most significant factor/ factors.
- Identify a cost effective combination for optimal quality recording.
- Validation of the identified recording combination.

CHAPTER 2

Review of Literature

A basic recording set up would require a combination of good quality hardware and software systems. In the simpler terms, this set up should minimally constitute a quality microphone along with supporting hardware and software for recording and a storage medium. The recording environment is another influential factor in speech recording. There have been fair number of researchers who investigated the factors that influence speech recording and conditions and the effect of certain variables in recording conditions. However, a conclusive research that suggests possible factors to be taken care for optimal speech recording was missing.

2.1 Factors affecting the quality of recording

It has been always difficult for a researcher or a clinician to arrive at an optimal recording configuration while recording speech samples for acoustic analysis for the purpose of assessment and diagnosis of voice and speech disorders. Factors affecting the quality of such recordings were investigated in the past. Parsa et al. (2001) probed the effect of the type of microphone on acoustic measures and found that, each of the microphones was modifying the frequency spectrum of the voice signal. Livijn (2004) investigated the acoustic effects of recording speech samples through four different media and the implications for forensic phonetics. He found that, the cassette tape recorder was effectively preserving formant frequencies compared to other media. Deliyski et al. (2005b) investigated the influence of sampling rate on accuracy and reliability of acoustic voice analysis and recommended a sampling rate of 26 kHz and above. Vogel and Morgan (2009) investigated the influence of microphone, environmental noise, analog-to-digital conversion and file format on the quality of recording and found that, all these factors have significant influence. Vogel et al. (2015) compared the performance of four recording devices. Speech samples were recorded simultaneously using a hard disk recorder coupled with a mixer and a table mounted speaker, a landline telephone, smart phone, and a laptop computer with USB connected microphone. They found that, the parameters of each of these recordings were significantly different from those of original speech samples.

Most of the International researchers have established the influence of several factors on the quality of recording of speech samples. They have also compared the recordings obtained through different devices. But none of them have arrived at an optimal configuration combining microphone, digitizing system as well as processing system. There is no reported evidence on the National status.

The essential factors that affect the recording of speech samples are those related to the recording components themselves, such as microphone characteristics, recording software, hardware, recording environment and file format with which the recorded signal is stored. These factors are discussed in the following sections.

2.1.1 Microphone

The sound, which is an acoustic signal, is converted into mechanical motion by the diaphragm of the microphone. The movement of the diaphragm is then converted into an electrical signal. The most common types of microphones are the dynamic microphones, condenser microphones and piezoelectric microphones. The recording capacities of different types of microphones depend on the variation in the characteristics of each type of microphones. These variations involve the differences in the mechanism with which changes in air pressure of sound energy is converted into equivalent electrical energy in different types of microphones, directionality or polar pattern, dynamic range, frequency response etc. Directionality of a microphone refers to the manner in which microphones capture the sound coming from different directions. For example; some microphones are omni-directional implying that those have the capability to capture sound from all directions preserving the same strength of signal. On the other hand, there are directional microphones that capture the sound incident from different directions with different strengths. Microphone with cardioid polar pattern is one such directional microphone that is sensitive to the input signal coming from front. This pattern is considered to be completely insensitive to sounds from the rear and less sensitive to sounds from the sides. The most contributing feature of these microphones that make them most suitable for acoustic analysis is the ability to discriminate between direct input signal and its reverberations resulting in less noisy recordings. Each microphone is unique in its frequency response, which refers to the range of frequencies that the particular microphone responds to. For the purpose of acoustic analysis, a microphone having flat and wide frequency response should be selected during recording. Yet another variable affecting signal recording is the distance and angle between the microphone and source of recording. Practically it has been found that there is approximately 6 dB dampening per doubling of distance between microphone and source of signal. Typically, a hand-held microphone should be placed at a distance of about 15 cm from the speaker. Ideally recordings should be carried out in a sound treated room or in a room with minimal noise.

Several studies have explored the effect of microphone type on speech recording. Titze & Winholtz (1993) explored the effects of microphone type and microphone placement with respect to source on voice perturbation measures by using two different types of microphones; condenser and dynamic. It was found that the perturbation measures were less affected in condenser microphones compared to dynamic microphones. In addition, it was also concluded that distance and angle of placement had effects on the perturbation measures of the recordings. Sensitivity of the microphone also had an influence on perturbation measures. Condenser microphones, being more sensitive than dynamic microphones, may be preferred for perturbation measures (Titze & Winholtz, 1993). Deliyski et al. (2006) observed that factors such as microphone, data acquisition (DA) system, and analysis software were influential on the voice quality measurements. Parsa et al., (2001) explored how microphone characteristics influence acoustic measures of voice. They examined how the choice of microphones influences the parameters of voice as well as how these effects could be compensated through filtering process by using one omni-directional and three cardioid microphones. They concluded that microphone characteristics were found to influence the input voice signal and affect the salient parameters of voice resulting in difficulty to classify normal vs. pathological voices.

2.1.2 Recording environment

The National Centre for Voice and Speech (NCVS) recommends that speech recording should be done in a sound treated room with background noise level less than 50 dB (www.ncvs.org). On the similar ground, Deliyski et al. (2005a) investigated how noise floor affects the accuracy, reliability and validity of acoustic voice quality measurements. They aimed at determining the critical noise levels that affects the validity of voice quality measurements as well as to recommend standards. Their results indicated that the recommended acceptable noise levels in a recording acoustic environment should be 30 dB or less. This implies that background noise level is an important factor altering the acoustic characteristics of speech signal.

Studies have reported that factors like recording environment, context, background noise and recording device affect the definite acoustic patterns of speech sounds as well as the overall quality of recorded samples (Vogel & Morgan, 2009). Ingrisano et al. (1998) studied the effects of background noise level on voice recording and concluded that as the background noise level increased, perturbation measures of jitter and shimmer were the most altered. Studies have also analyzed the effects of computer fan noise on the voice measures comparing normal and pathological voices in female subjects and concluded that fundamental frequency was relatively resistant to environmental noise and was least affected in pathological voice. They also reported that jitter and shimmer measures were most affected with background noise and the levels increased as the noise floor increased (Perry et al., 2000). Electronic noise of the laptop or PC may also contribute to the noise in the recorded signal.

2.1.3 Hardware

The equipment variables that affect the acoustic measures include analog-digital (A/D) conversion hardware and other amplifier features. Deliyski et al. (2006) observed that data acquisition system were highly influential on fundamental frequency of the recorded samples. Deliyski et al. (2005a) studied how the data acquisition hardware and the microphone influence acoustic features of the input speech signal. Three software systems were used in the study that recorded and measured 2000 sustained phonation samples. The discretization error and the dynamic range of the different data acquisition hardware were computed. It was concluded that high quality professional grade acquisition hardware could be considered for efficient acoustic analysis. According to Titze et al. (1987) 'one of the most important methodological factors in perturbation analysis is temporal resolution'. In this regard it could be inferred that any alteration that affects the temporal aspects of the input signal can contribute to significant deviations in the acoustic measures as well. Sampling is an important part of the analog-digital conversion wherein the continuous-time signal is transformed into a discrete-time signal and the number of discrete values assigned per second refers to the sampling rate (Fs, Hz). According to Nyquist theorem, the sampling rate (Fs) should be at least twice as high as the highest frequency component present in the signal. Studies have investigated the influence of sampling rate on the acoustic measures of voice and have inferred that the sampling rate (Fs) recommended for acoustic analysis of voice is above 26 kHz (Deliyski et al., 2005b).

Livijn (2004) investigated the effects of recording speech through different recording and storage media on the acoustic characteristics of speech sounds as well as forensic implications of it. They recorded a phonetically rich material through four recording devices and the results indicated that cassette tape recorder was effectively preserving formant frequencies compared to other media. It was also concluded that, from a forensic point of view, recordings using media such as micro cassettes and mobile phones cannot be considered as optimal. Vogel et al. (2015) compared four recording devices. Speech samples were recorded simultaneously using a hard disk recorder coupled with a mixer and a table mounted speaker, a landline telephone, smart phone, and a laptop computer with USB connected microphone. They found that, the parameters of each of these recordings were significantly different from those of original speech samples. Lee (2018) compared the voice samples recorded using Computerized Speech Lab (CSL-Model 4150B) with android smartphone (Samsung Galaxy Note 5, SM-N920). Acoustic parameters considered for this study included jitter percent (% Jitt), shimmer percent (% Shim), noise-to-harmonic ratio (NHR), Cepstral peak prominence (CPP), L/H ratio, Cepstral Spectral Dysphonia Index (CSID). Results suggested a positive correlation between the same parameters of both devices. No significant differences were observed between the devices.

2.1.4 Software and file format

Burris et al. (2014) compared the accuracy and comparability of four acoustic analysis software packages such as Praat (Version 5.1.31; Boersma & Weenink, 2010), WaveSurfer (Version 1.8.5; Sjolander & Beskow, 2005), TF32 (Time frequency analysis software, Milenkovic, 2010), and CSL (Computerized Speech Laboratory Model 4500, Version 2.7.0; Kay Elemetrics, 1996). The results showed that all the four software packages generated accurate and comparable data. Thus the analysis software may not have any effect on the parameters and hence, the effect of analysis software is not investigated in this study.

The file format in which the recorded samples are stored also influences the quality of the signals (Vogel & Morgan, 2009). '.avi' and '.wav' file formats store the recorded samples without compressing any information. Vogel and Morgan (2009) states that the integrity of the recorded samples will be maintained if the information is stored in '.avi' and '.wav' file formats and will result in faithful reproduction of the original sound. They also mentioned that in MP3 format, in order to reduce the size of the file, most of the audio details are lost. This will lead to loss of signal quality, which in turn affects the reliability of the results of acoustic analysis.

2.2 Parameters for judging the deviation of recorded speech from natural speech

The deviation of the recorded speech samples from their originality may be documented with the help of several parameters. The parameters which get affected due to the variation in characteristics of the components of the recording system are discussed below:

2.2.1 Fundamental frequency

The fundamental frequency of a speech signal (F0) refers to the approximate frequency of the (quasi-) periodic structure of voiced speech signals. Deliyski et al. (2005a) investigated the effect of microphone, environmental noise, data acquisition hardware, and analysis software on the recorded voice quality. They observed that if the sampling frequency of the data acquisition hardware is less than 10 kHz, the fundamental frequency in the recorded samples will change significantly. Livijn (2004) observed that F0 is lost during recording when the speech samples get transmitted through the different constituents of the recording system such as microphone, A/ D convertor, storage media, etc.

2.2.2 Formant frequencies

A formant frequency is a concentration of acoustic energy around a particular frequency in the speech wave. There are several formant frequencies, each at a different frequency, each formant frequency corresponds to a resonance in the vocal tract. The relationship between the perceived vowel quality and the first two formant frequencies is well established. Livijn (2004) compared formant frequencies estimated from the recordings made with a cassette recorder, micro cassette recorder and a mobile phone. Livijn (2004) observed that in comparison to a reference recording system, the largest deviation was found in the recordings made with micro cassette recorder followed by the mobile phone recording and cassette recording.

2.2.3 *Durations*

Transition duration is the duration of time during which there are rapid spectral changes in the formant frequencies after the release of occlusion. Liberman et al. (1954) investigated the role of consonant-vowel transition in the perception of stop and nasal consonants. Their results indicated that the second formant frequency transition is an important cue for distinguishing between different voiceless stops as well as between different voiced stops.

Closure duration refers to the total time of closure. Gordon-Salant (1986) evaluated the effect of three acoustic modifications (consonant duration increased by 100%; consonant-vowel ratio increased by 10dB, and both) on consonant recognition in young and elderly normal-hearing subjects. He measured percent-correct nonsense syllable recognition. Results of this study indicated that an increase in consonant duration improved speech intelligibility.

Voice onset time (VOT) is the interval between the release of the complete articulatory constriction and the onset of quasi-periodic vocal fold vibration. VOT is positive for unvoiced consonants and negative (lagging) for voiced consonants. Niyogi and Ramesh (1998), in a study on distinctive features of speech as an error correcting device to discriminate between confusable pairs in a speech recognizer, reported that VOT provides superior separability compared to spectral cues. They also found that when VOT was used as a cue, it significantly improved recognition scores.

2.2.4 *Spectral tilt*

Spectral tilt is estimated as the slope of the least squares linear fit to the log power spectrum of the speech signal (Enflo, 2009). It shows the distortion observed in the spectrum when the speech signal is passed through a linear time-invariant filter, like the components of a recording system. Childers and Lee (1991) observed spectral slope of the source excitation as one of the factors influencing vocal quality. Murphy (2001) established spectral tilt as a reliable parameter to estimate the noise embedded in the speech signal and subsequently to judge the voice quality. Leindhin and

Murphy (2005) used spectral tilt as a noise estimator and suggested its potential use in expressing the voice quality of a speaker.

2.3 Summary

The relative approximation that could be drawn between the recorded speech and the natural speech has always been a point of query because of the influential factors discussed above. There could be the influence of any of these factors in a recording situation resulting in changes of the acoustic properties of the speech as compared to natural speech. The acoustic properties such as fundamental frequency, formant frequencies, transition duration, closure duration, voice onset time and spectral tilt are found to influence the quality of the recordings. The weakest link in the recording configuration will influence the quality. Considering these, it is important to analyse the samples recorded by different laptop microphone combinations and to arrive at an optimal laptop configuration with an appropriate microphone that could be recommended for acquisition of speech samples in everyday clinical and research activities. In India, very limited studies have been conducted that explore how the acoustic characteristics of the different classes of sounds vary with the components of the recording set up. This raises the need for the present study.

CHAPTER 3

Method

The aim of the present study was to identify and validate a cost effective configuration for optimal recording of speech samples for speech analysis. The study also identified the most significant factor out of fundamental frequency, formant frequencies, durations and spectral tilt which gets affected by the recording process.

3.1 Participants

The speech samples were obtained from ten normal healthy individuals (five males and five females). All the participants were native Kannada speakers between 21 and 36 years of age. The participants were selected through a structured interview to ensure that none of them have any kind of neurological, psychological or sensori-motor impairments and are nonsmokers and nonalcoholic. A written consent was taken from the participants before recording. Ethical clearance was also obtained from the study centre. For validation, speech samples were obtained from another group of six participants (three males and three females) using the identified optimal recording configuration.

3.2 Material

The syllables consisted of eight stop consonants in CV context (/pa/, /ṭa/, /ka/, /ba/, /ḍa/, /ga/,/t̪ha/, /d̪ha/). Printed text of the syllable material was given so that the participant could read out the syllables.

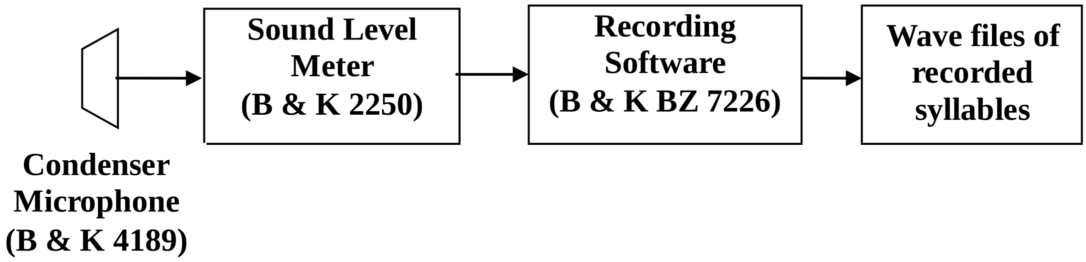
3.3 Instrumentation

3.3.1 Benchmark configuration

A high quality recorder coupled with a condenser microphone was used as the benchmark device in a similar study by Vogel et al. (2015). Similarly, a benchmark configuration which consisted of a high quality recording system coupled with a precision condenser microphone was used in the present study. This benchmark system served as a reference for comparing the performance of different laptop microphone combinations. Microphone of the benchmark system was having a sensitivity of 50 mV/Pa, frequency response in the range of 6.3 Hz to 20 kHz, and a dynamic range of 14.6 dB to 146 dB. The benchmark recording system possesses full 130 dB dynamic range and is equipped with 24-bit recording at 48 kHz sampling frequency. The benchmark configuration is depicted in Figure 1.

Figure 1

The benchmark configuration



3.3.2 Laptop – Microphone Combinations

Sixty different combinations of recording were set up with ten laptops of different configuration, each one with a different sound card, with different processing features tethered with six microphones (that can be coupled with laptops). The different laptop–microphone (L-M) combinations are shown in Table 1 below.

Table 1

Configuration of laptop, sound card specifications and microphone type

	Laptop configuration	Sound card specifications		Microphone type
L1	Intel Core i7-4110 CPU 2.00 GHZ, with Windows 8.1, 64 bit OS and 4GB RAM	24bit, 192000Hz	M1*	Inbuilt microphone of the laptop
L2	Intel Core i5-6200 CPU 2.3 GHZ, with Windows 8.1, 64 bit OS and 4GB RAM	24bit, 96000Hz	M2	External Mic Creative HS 150
L3	Intel Core i5-6200 CPU 2.3 GHZ, with Windows 8, 32 bit OS and 4GB RAM	24bit, 88200Hz	M3	External Mic Creative HS 390
L4	Intel Core i5-5200 CPU 2.2 GHZ, with Windows 8.1, 64 bit OS and 8GB RAM	24bit, 48000Hz	M4	External Mic i ball rocky
L5	Intel Core i5-2430 CPU 2.4 GHZ, with Windows 8, 64 bit OS and 4GB RAM	24bit, 44100Hz	M5	External MicFrontech Jil-3442
L6	Intel Core i5-4200 CPU 1.6 GHZ, with Windows 7, 32 bit OS and 4GB RAM	16bit, 192000Hz	M6	USB External Mic Creative HS 720
L7	Intel Core i5-2450M CPU 2.50 GHZ, with Windows 8 PRO, 64 bit OS and 4GB RAM	16bit, 96000Hz		
L8	Intel Core i3-2350 CPU 2.30 GHZ, with Windows 7, 64 bit OS and 2GB RAM	16bit, 88200Hz		
L9	Intel Core i3-M 380 CPU 2.53 GHZ, with Windows 7, 32 bit OS and 4GB RAM	16bit, 48000Hz		
L10	Intel Core i3-2348M CPU 2.3 GHZ, with Windows 8.1, 32 bit OS and 2GB RAM	16 bit, 44100Hz		

*Note: M1 denotes inbuilt microphone of the corresponding laptop.

3.4 Procedure

The participants were seated comfortably in a sound treated room with the recording microphone placed in front of the participant at a distance of 15 cms. The distance between the participant and the microphone was maintained at 15 cms for all the recording combinations. The participants were asked to read the syllables in a normal conversational voice at a comfortable pitch and loudness. Each syllable was repeated twice maintaining a constant inter syllable interval. The speech uttered by the participants were recorded with the benchmark system as well as with sixty different combinations of the recording set up as listed in Table 2. Recording was done in a single session in ten steps. In each step, syllables were recorded with six laptop microphone combinations and the benchmark system. Thus, recording on all sixty laptop microphone combinations were completed (syllables repeated ten times by the participants). The recording was made on the benchmark system in all the ten steps. The recording level was fixed at 75% level, in all the combinations. For all combinations, the recordings were stored in '.wav' format, which is a loss less compression format. For validation, the same procedure was repeated for another six participants, recording the samples with the identified optimal configuration and the benchmark system, following comparison of the parameters with the benchmark system.

Table 2

Recording combinations

Recording combination	Number of combinations
Laptop configuration L1 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L2 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L3 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.

Laptop configuration L4 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L5 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L6 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L7 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L8 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L9 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Laptop configuration L10 paired with microphones M1, M2, M3, M4, M5 and M6 respectively.	6 Nos.
Benchmark system	1 No.
Total Number of recording situations	61 Nos.
Total Number of recorded speech samples	61 Nos.x16 syllables= 976 Nos. 976 Nos.x 10 subjects = **9760**

3.5 Acoustic measures investigated in this study

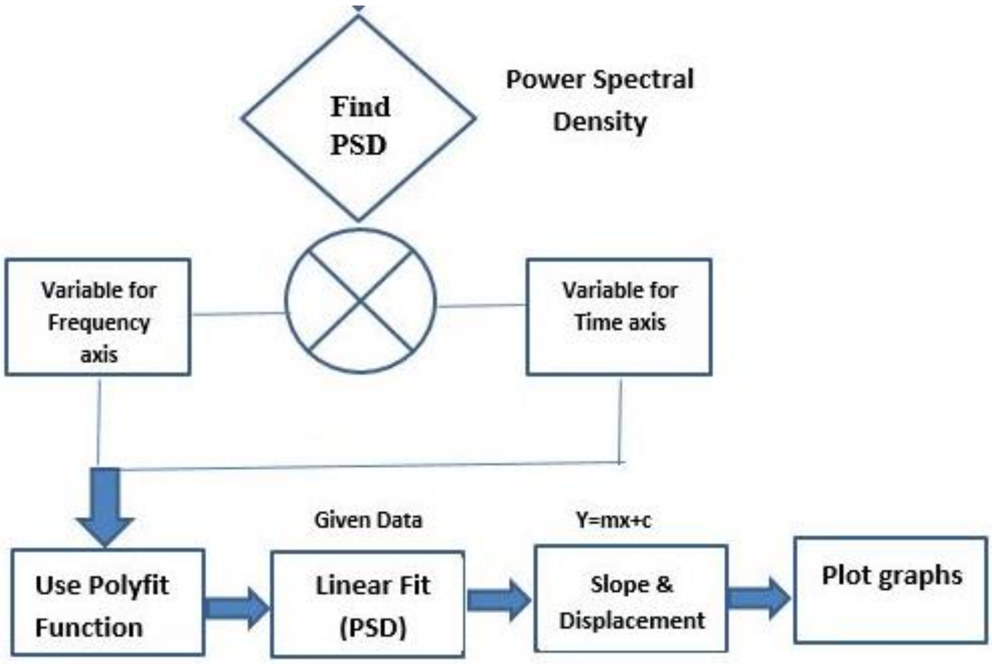
The following acoustic parameters were used to compare the speech samples recorded through each of the L-M combinations with the speech samples recorded through the benchmark system:- a. Fundamental frequency (F0), b. Formant frequencies (F1, F2), c. Voice Onset Time (VOT), d. Transition duration, e. Closure duration and f. Spectral tilt.

3.5.1 Measurement of spectral tilt:

Using the method proposed by Enflo, 2009, spectral tilt was estimated for the syllables recorded with the benchmark system as well as with 60 laptop microphone combinations. The slope of least squares linear fit to the log power spectrum of the speech stimuli was considered as spectral tilt. Wave forms of the recorded syllables were acquired and the log power spectrum were extracted using Pulse- Reflex tool of Bruel & Kjaer (B & K). From the log power spectrum, spectral tilt was estimated using the code written in Matlab as per the flow chart in Figure 2.

Figure 2

Flowchart of procedure for spectral tilt measurement



3.5.2 Measurement of VOT and Closure duration:

VOT and closure duration were measured manually from each recorded sample using Adobe Audition.

3.5.3 Measurement of F0, transition duration and formant frequencies:

Measurement of fundamental frequency (F0), formant frequencies (F1, F2) and transition duration were carried out using Praat software. While measuring F0, F1 and F2 only the vowel part of the CV syllable was considered. The range of frequencies set for F0 analysis in Praat was 75 - 300 Hz, for a male and 100 -600 Hz, for a female. Maximum number of formants to be extracted was set as two.

3.6 Analyses

The estimated parameters of the samples recorded with each of the laptop-microphone combinations were compared with those of the recordings obtained with the benchmark recording system. The obtained values were tabulated and were statistically analyzed using SPSS. Since the data did not fall in a normal distribution curve, non-parametric tests were used. Mean, median and SD of the values of the respective parameter of all the 10 speakers has been calculated for each syllable.

CHAPTER 4

Results

The objective of the current study was to investigate the effect of combinations of different laptop configurations, sound cards and microphones on the estimation of fundamental frequency, formant frequencies, durations and spectral tilt of the recorded speech samples by comparing these estimates with those of a benchmark system. The study also investigated the most significant parameter, as well as the effect of gender on the most significant parameter. The study identified a cost effective configuration for optimal quality recording. Identified configuration was validated by recording speech samples from another group of subjects and comparing with the benchmark system.

The speech samples acquired through each recording combination were subjected to acoustic analyses using Praat, Adobe Audition and Pulse-Reflex tool. The results of the analyses were tabulated in MS Office Excel and were subjected to statistical analysis using SPSS (Version 20.0). Since most of the data did not fall under a normal distribution curve, non-parametric tests were carried out for the statistical analysis. The results of the study are provided under the following subsections.

4.1 Characteristics of participants

Ten normal healthy individuals (five males and five females), who were native Kannada speakers between 21 and 36 years of age participated in the study. Mean age of the participants was 24.1 (SD = 3.7) years. Six normal healthy individuals (3 males and 3 females) aged between 21 and 36 years (mean age = 23.5, SD = 2.8 years) participated in the validation process.

4.2 Effect of different laptop configurations, sound cards and microphones on the fundamental frequency, formant frequencies, durations and spectral tilt

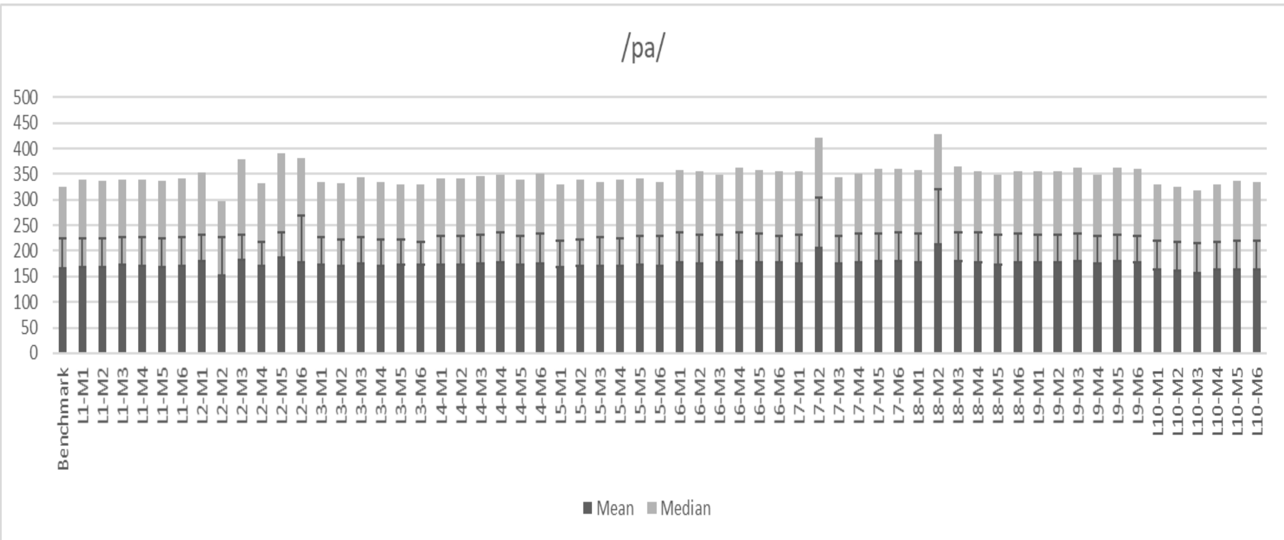
The data comprising eight CV syllables recorded from 60 laptop-microphone combinations were statistically analyzed to find the extent of variation in the fundamental frequency, formant frequencies, duration and spectral tilt in comparison with the benchmark system.

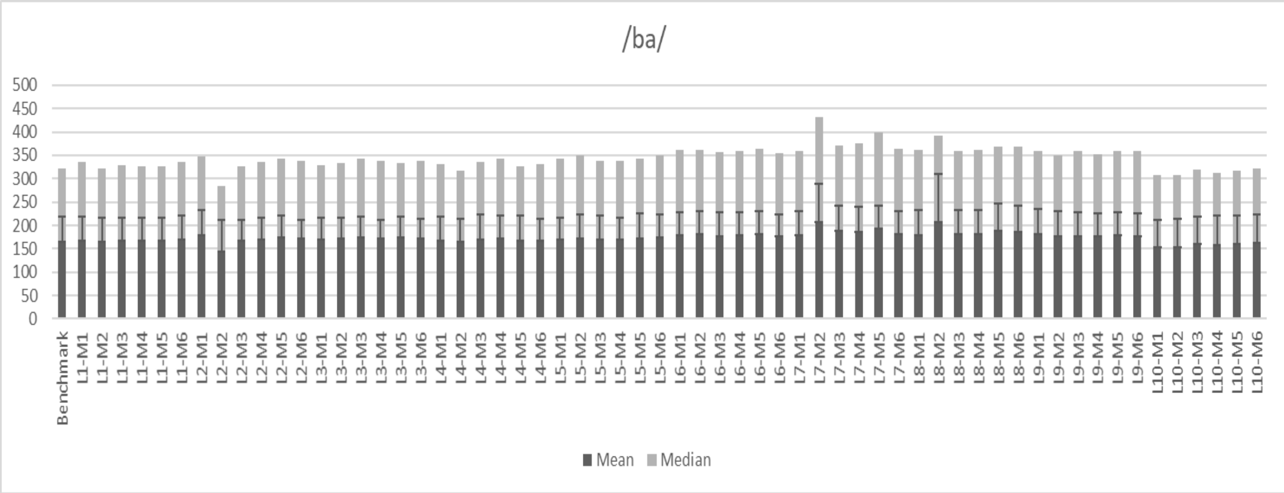
4.2.1 Effect of different laptop configurations, sound cards and microphones on fundamental frequency

Descriptive analysis was done to find out the mean, standard deviation and median values of fundamental frequency (F0) for the samples recorded by all the L-M combinations and that of the benchmark system for each of the syllables. The results are given in Figure 2. Test for normality was carried out and the data did not fall in a normal distribution curve. Hence non-parametric tests were executed on the data.

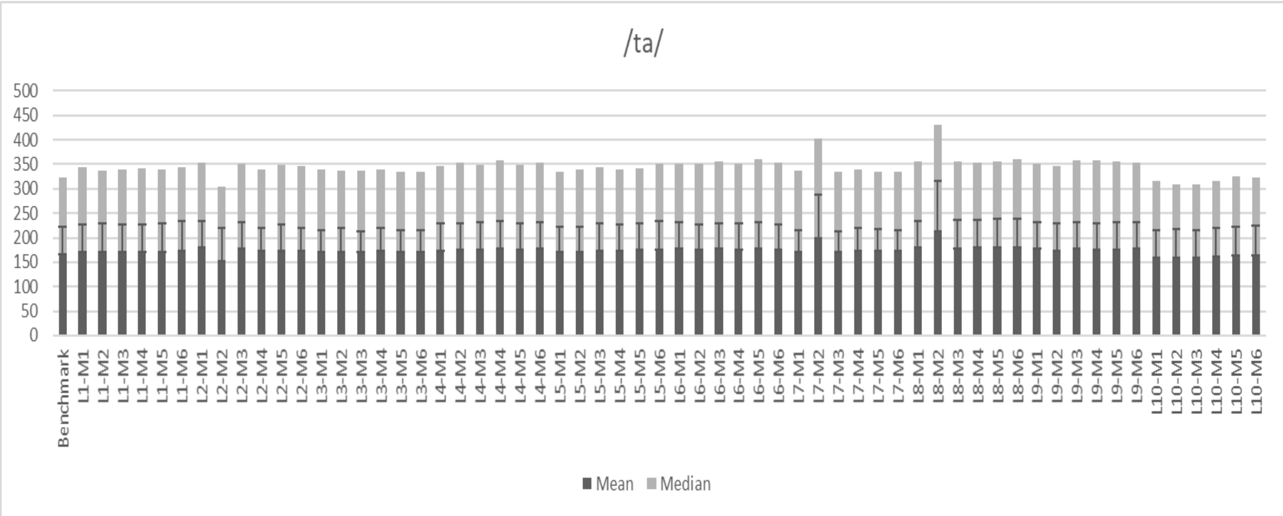
Figure 2

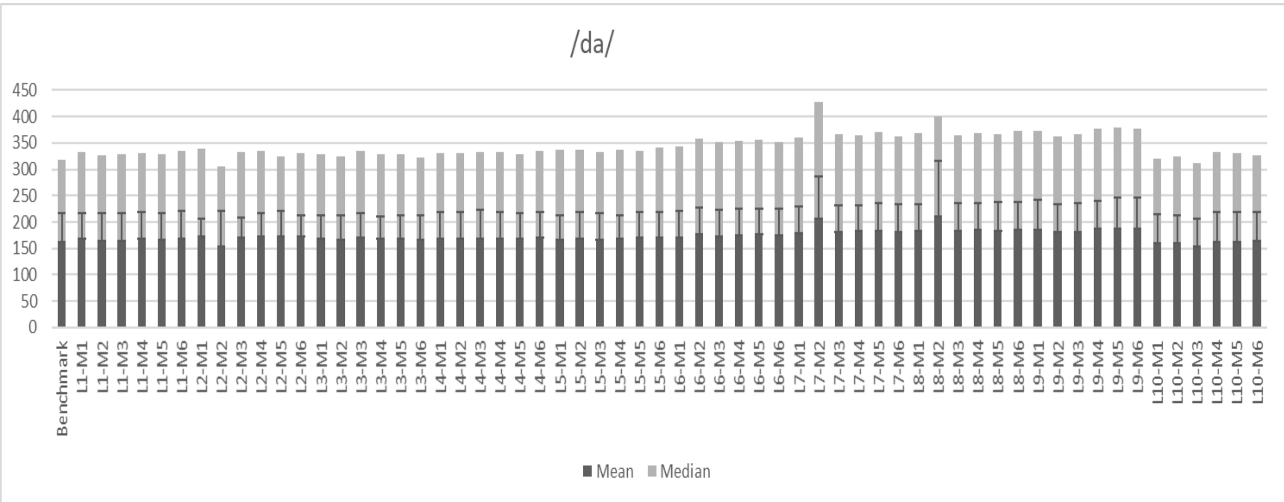
a. Mean, SD and median values of F0 (Hz) for sounds /pa/ and /ba/ for different recording combinations



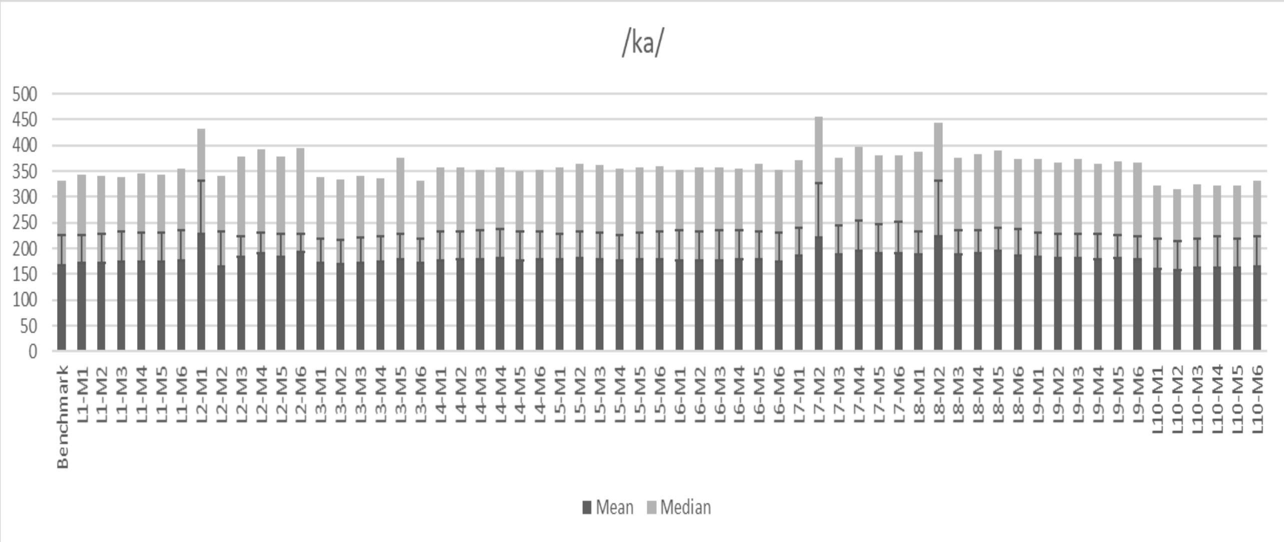


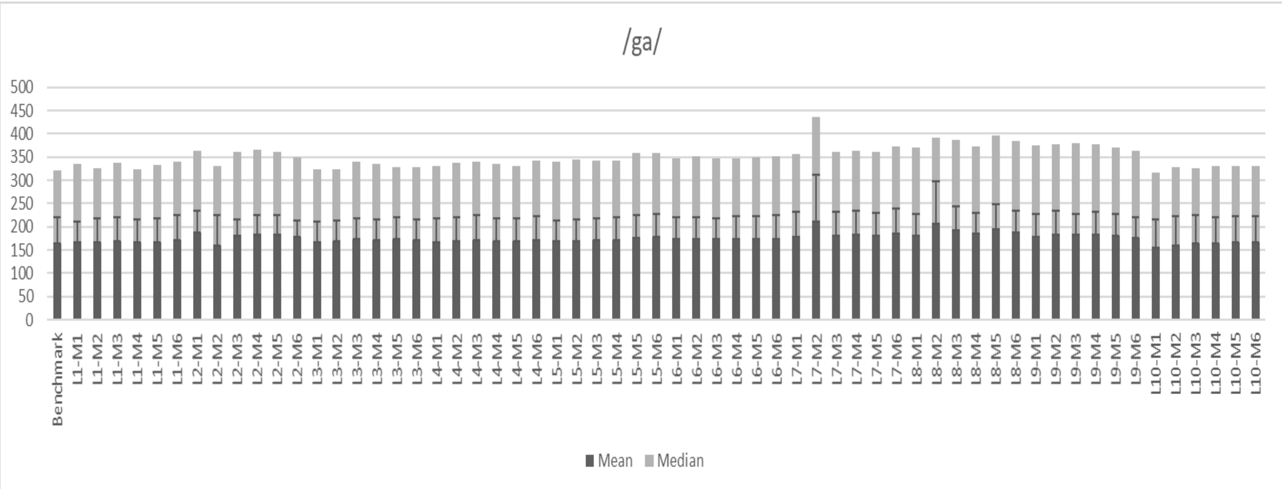
b. Mean, SD and median values of F0 (Hz) for sounds /ta/ and /da/ for different recording combinations



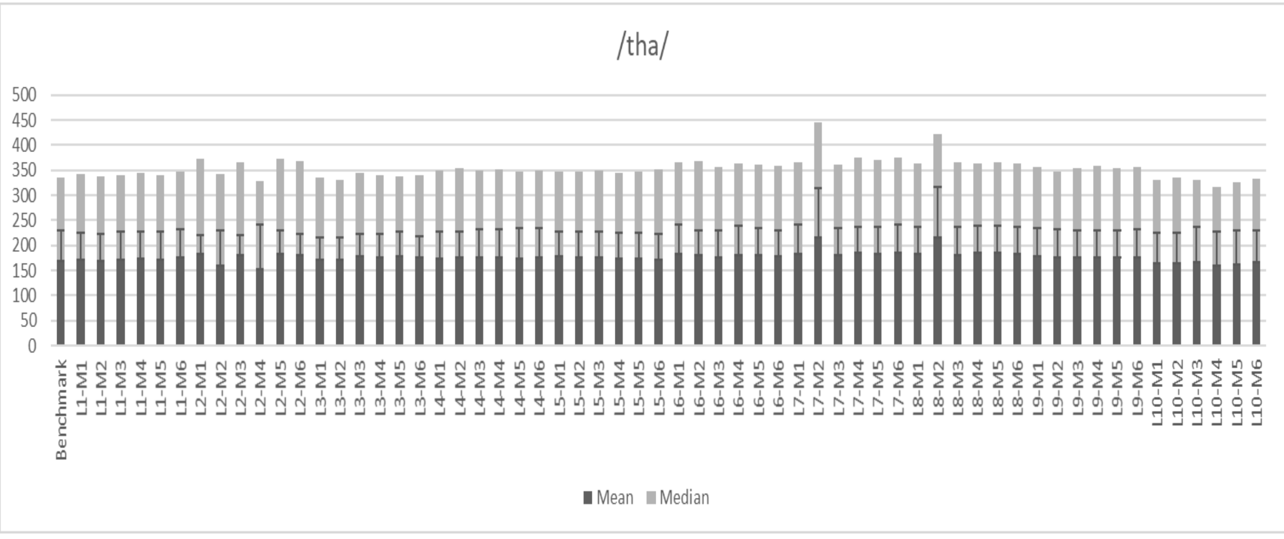


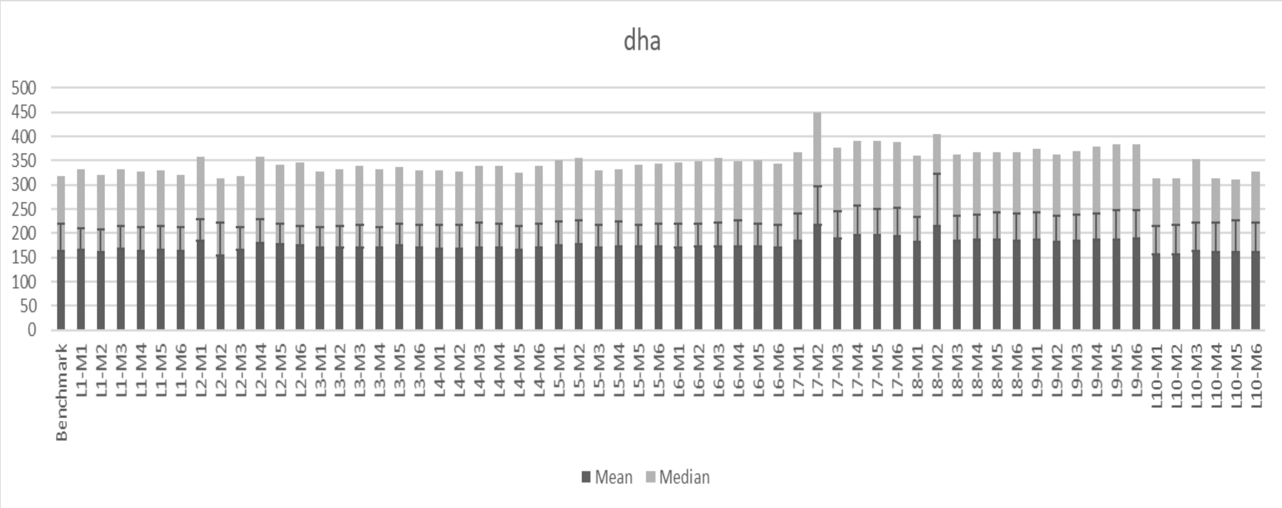
c. Mean, SD and median values of F0 (Hz) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, SD and median values of F0 (Hz) for sounds /tha/ and /dha/ for different recording combinations





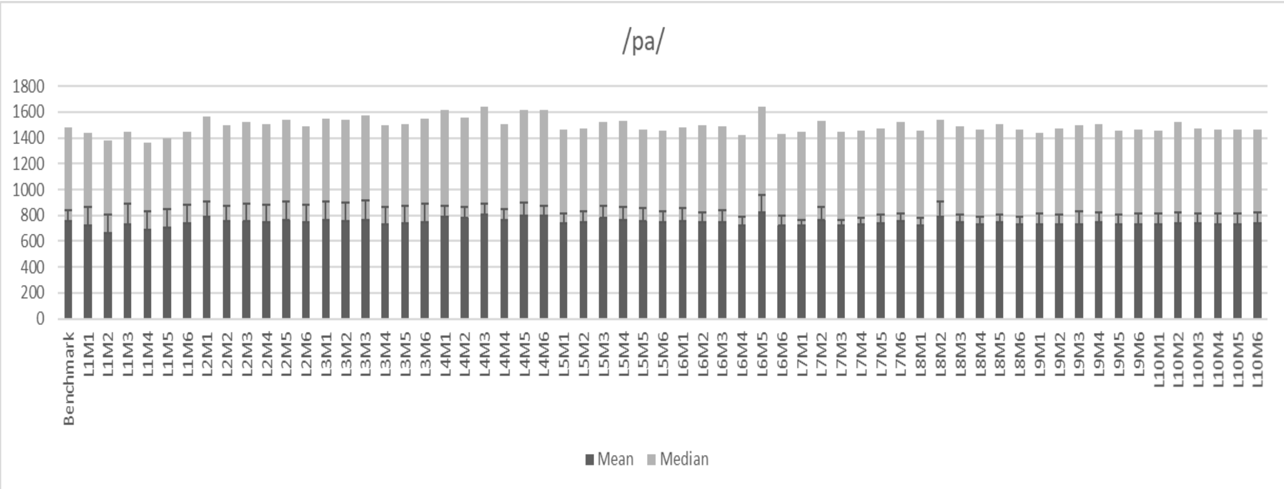
Non-parametric Friedman test was employed to compare the acoustic measures of each of the L-M combinations with that of the benchmark system. Significant difference was observed for most of the sounds, in most of the combinations. Wilcoxon signed-ranks test was done to compare each of the L-M combinations with the benchmark system. The obtained data was then arranged manually and the L1-Mn, L3-Mn and L10-Mn (where 'n' indicates the microphone number from 1-6) combinations were found to have no significant difference with the benchmark system for most of the syllables. For all eight consonants, the L3-Mn and L10-Mn combinations showed no significant difference, whereas L1-Mn showed no statistically significant difference for four out of the eight syllables. Thus, L3-Mn and L10-Mn were concluded to be the configuration that is least deviant from the benchmark configuration. Among the L3-Mn and L10-Mn combinations, the configuration which is most similar to that of the benchmark was found out manually by comparing the median values (Table 3). Thus, it was found that the L3-M1 and L10-M1 were the closest combinations to the benchmark system in five (/pa/, /ta/, /ga/, /tha/ & /dha/) of the eight syllables.

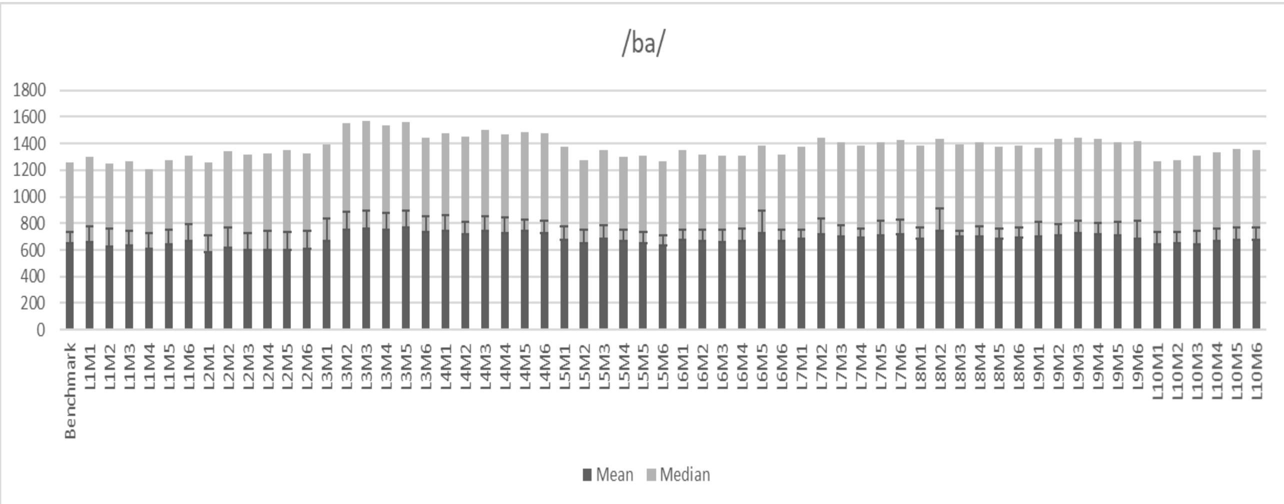
4.2.2 Effect of different laptop configurations, sound cards and microphones on formant frequencies (F1 & F2)

The mean, median and standard deviation of formant frequencies F1 & F2 were calculated for all L-M combinations against that of the benchmark system for each of the syllables and is shown in Figures 3 and 4 respectively.

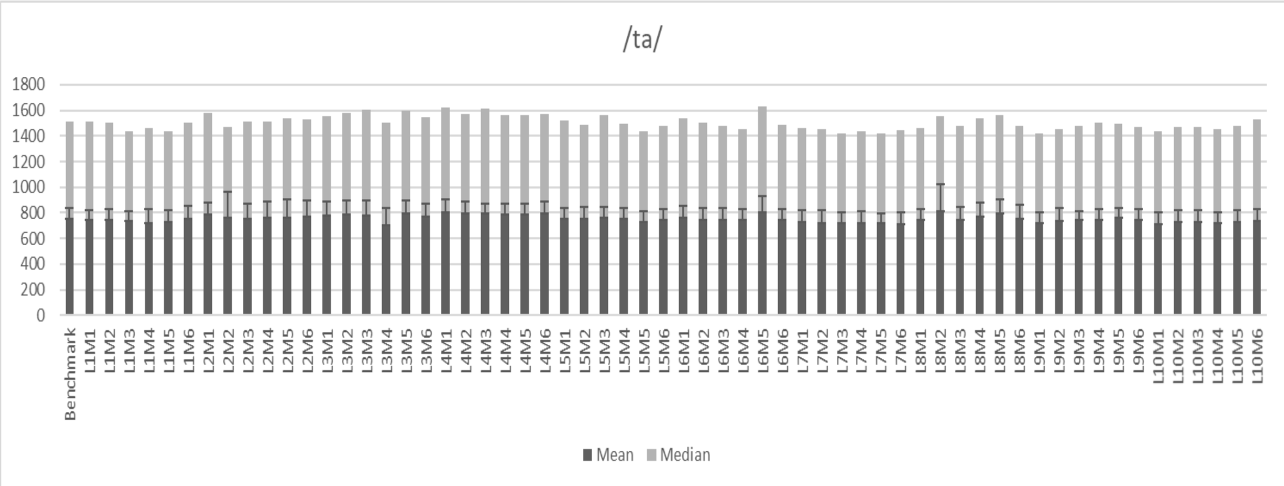
Figure 3

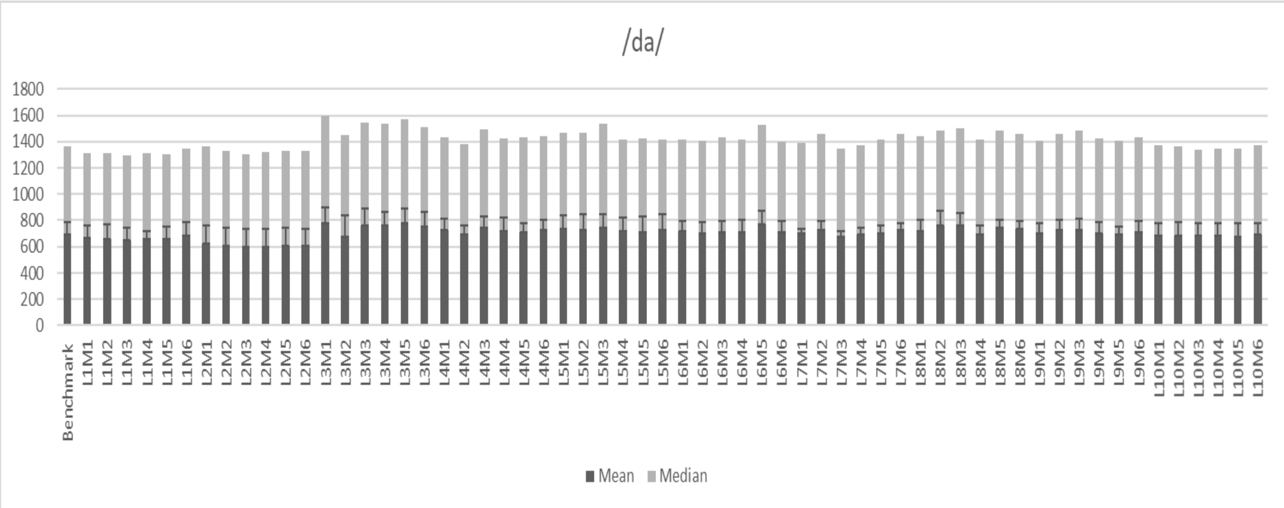
a. Mean, SD and median values of F1 (Hz) for sounds /pa/ and /ba/ for different recording combinations



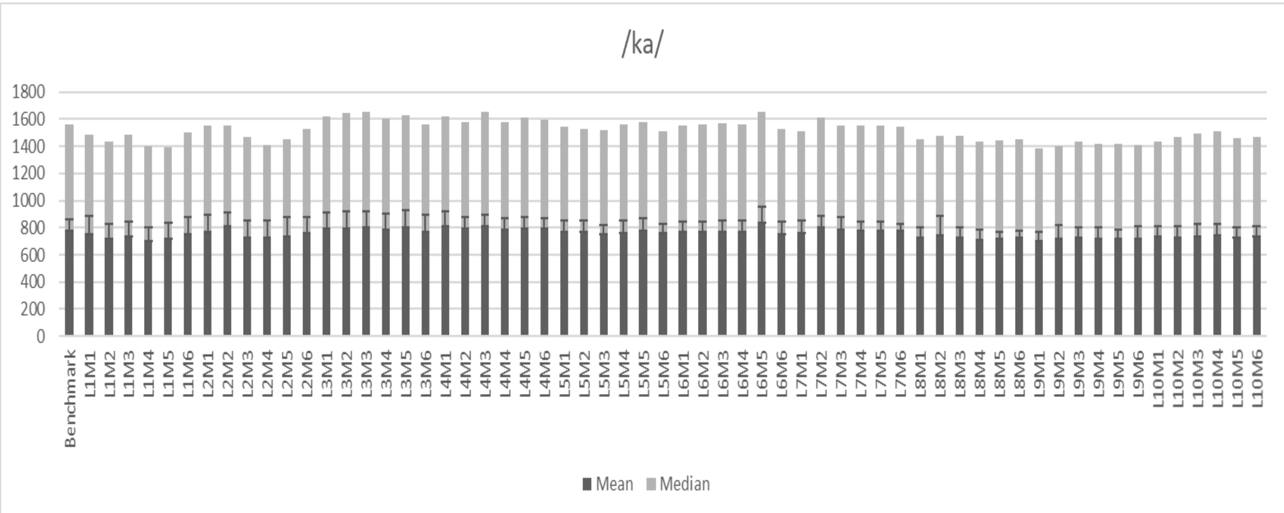


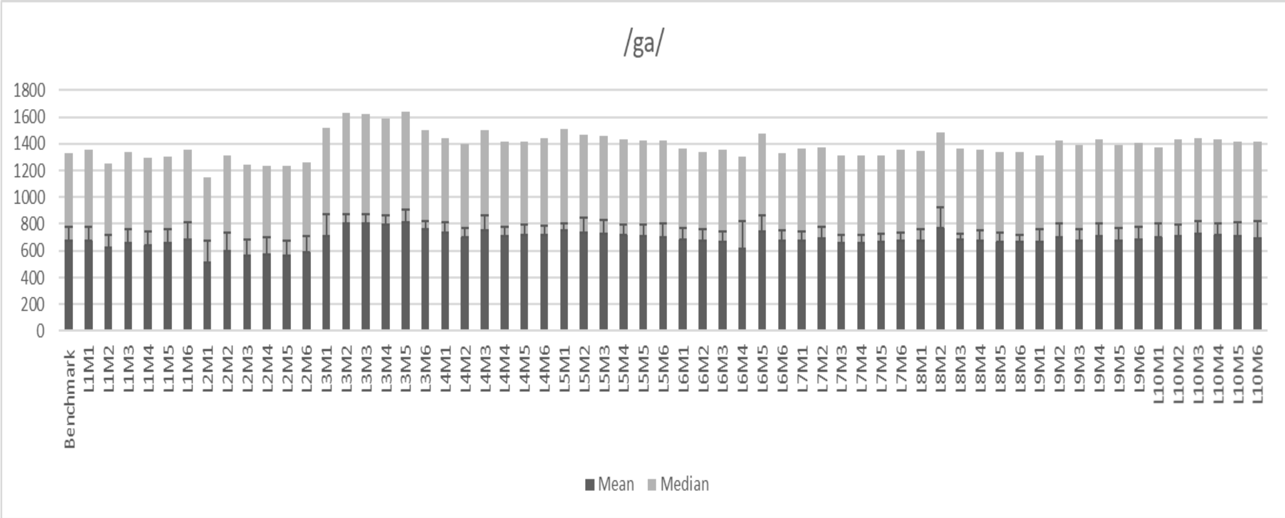
b. Mean, SD and median values of F1 (Hz) for sounds /ta/ and /da/ for different recording combinations



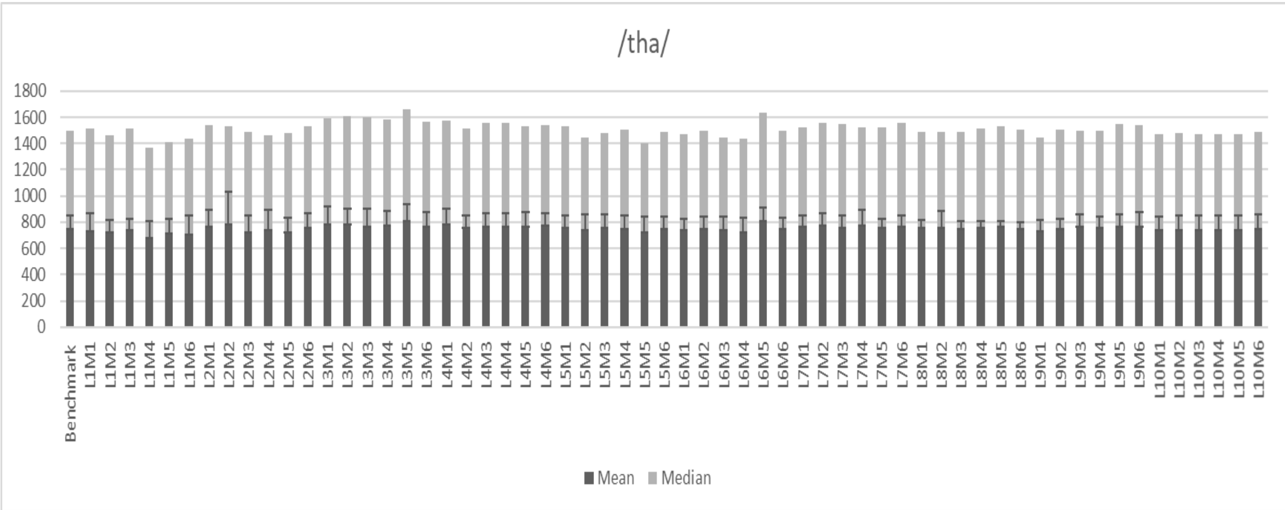


c. Mean, SD and median values of F1 (Hz) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, SD and median values of F1 (Hz) for sounds /tha/ and /dha/ for different recording combinations



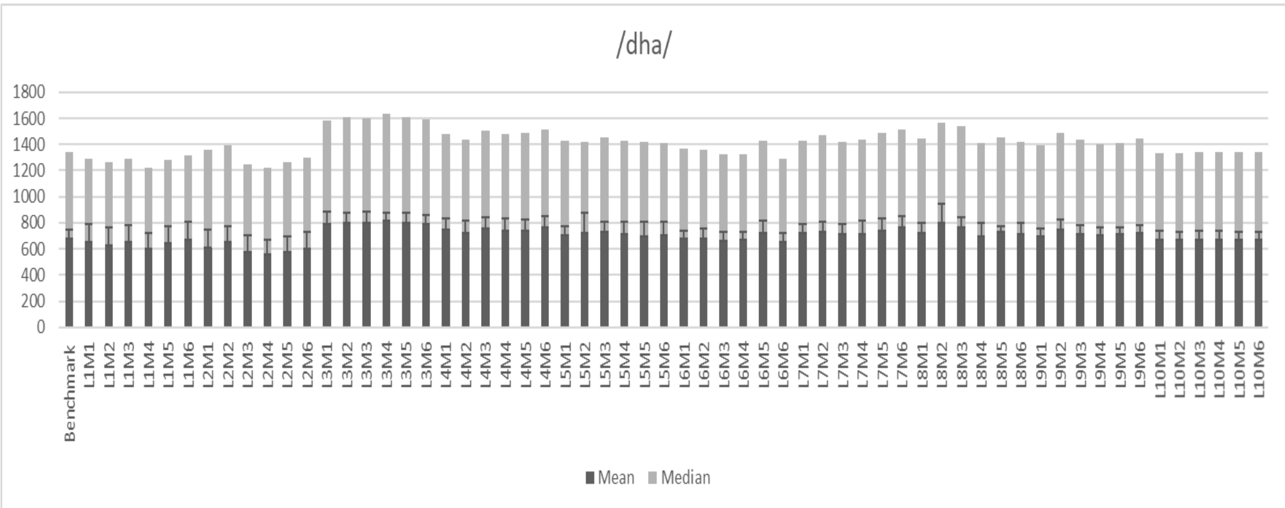
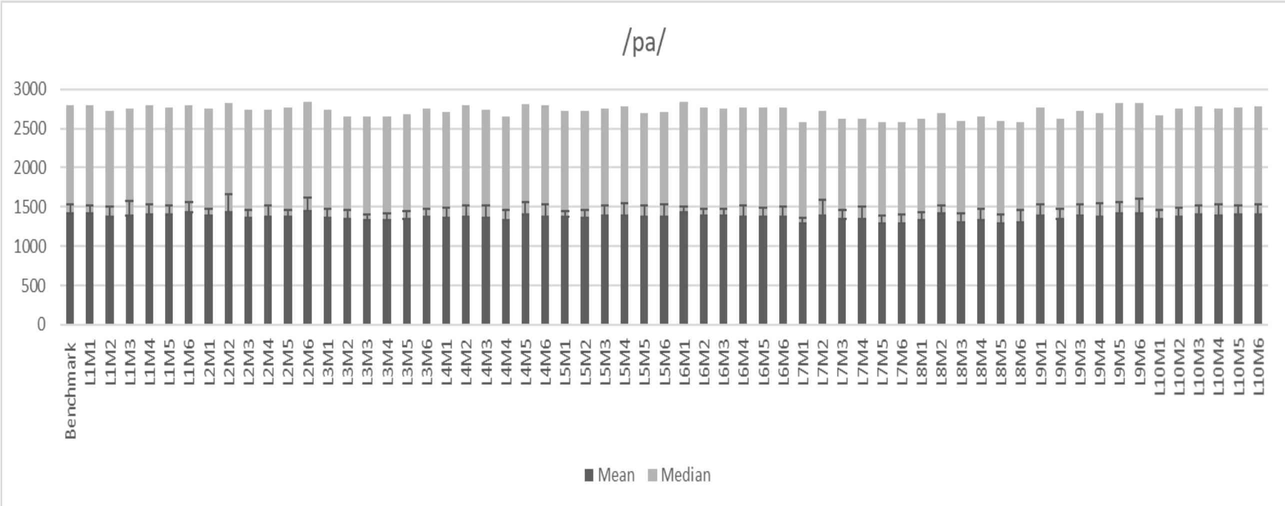
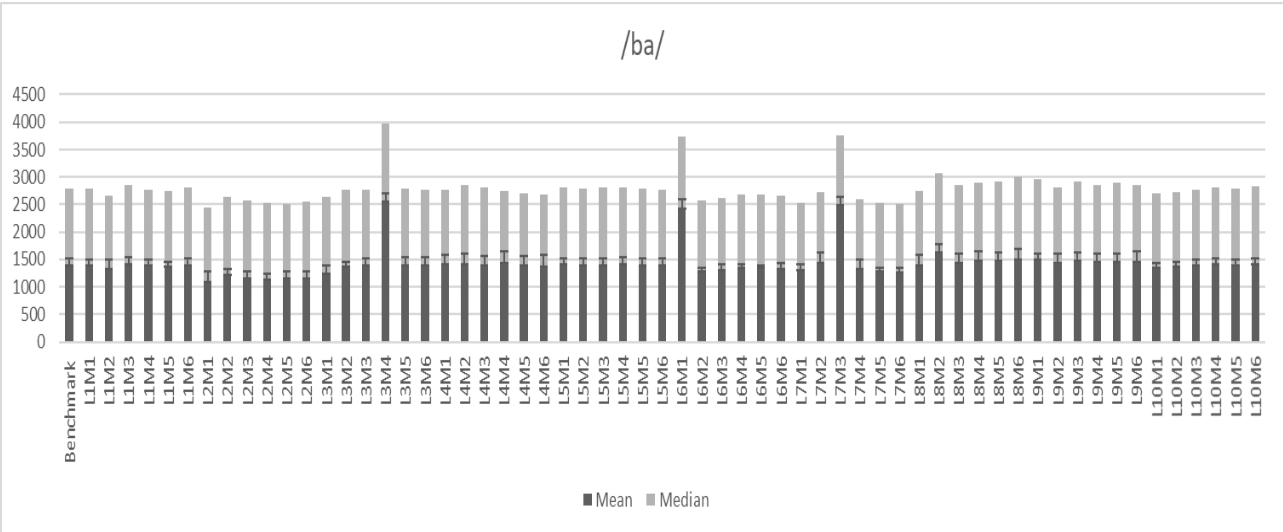


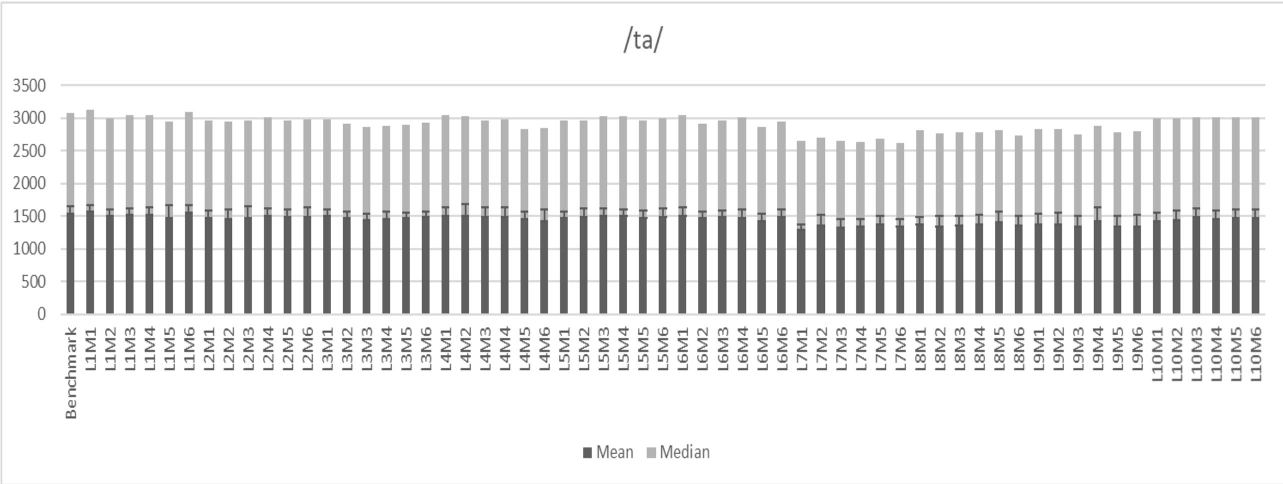
Figure 4

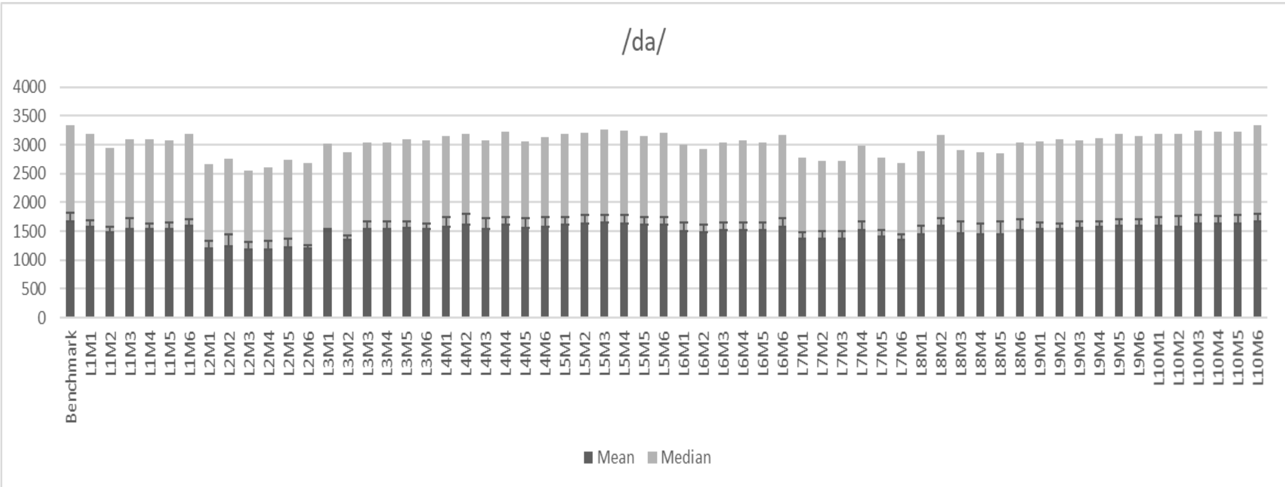
a. Mean, SD and median values of F2 (Hz) for sounds /pa/ and /ba/ for different recording combinations



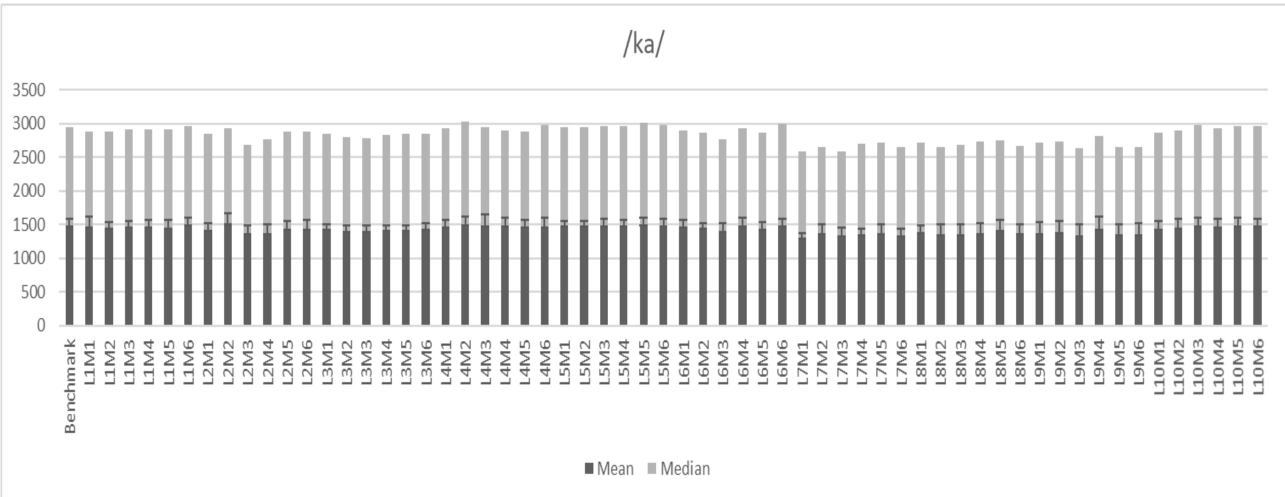


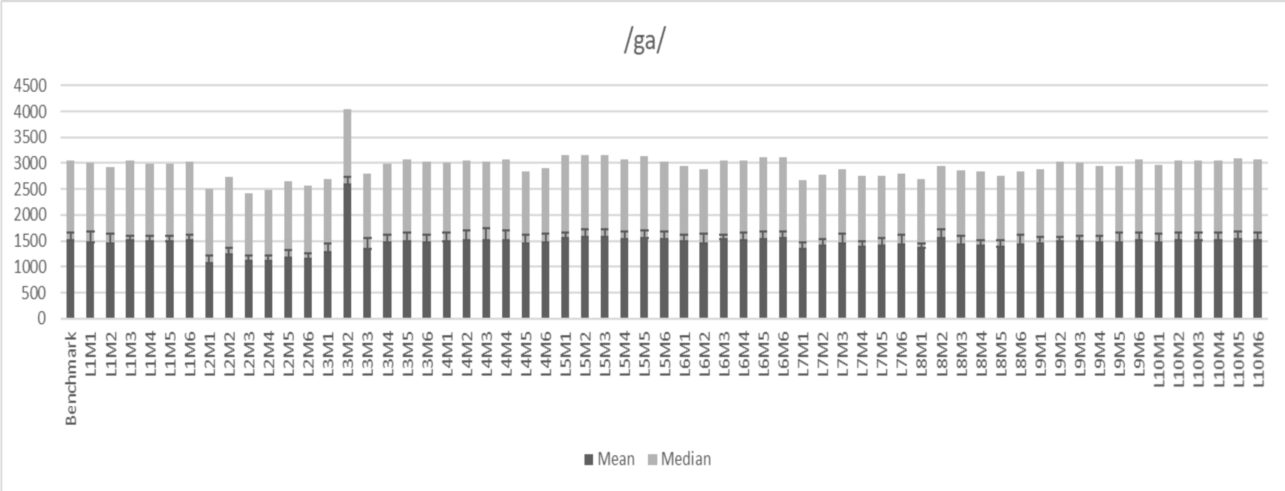
b. Mean, SD and median values of F2 (Hz) for sounds /ta/ and /da/ for different recording combinations



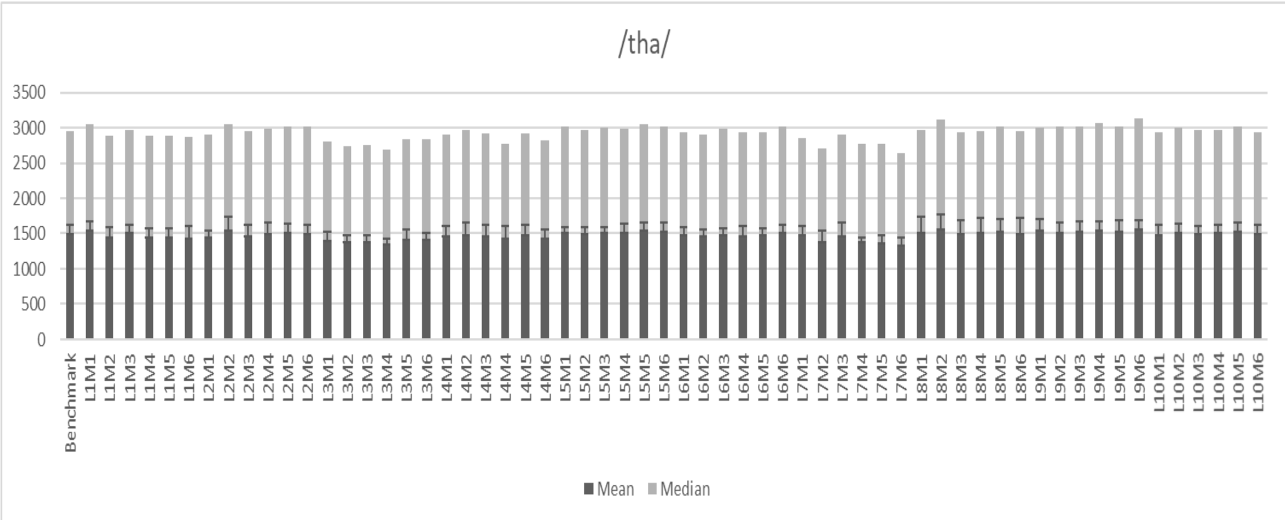


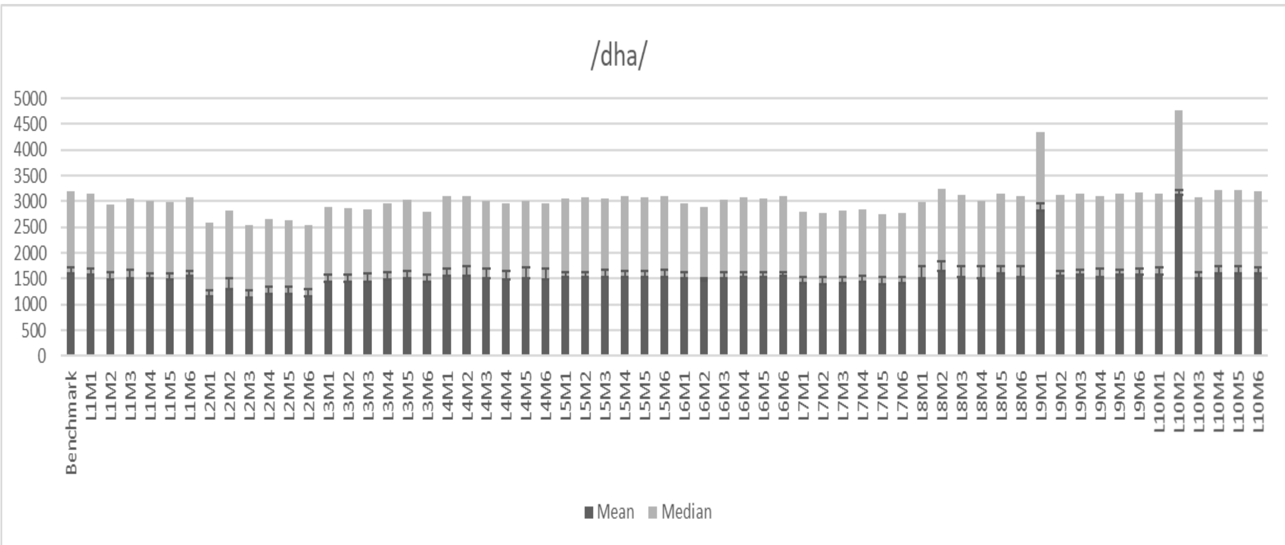
c. Mean, SD and median values of F2 (Hz) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, SD and median values of F2 (Hz) for sounds /tha/ and /dha/ for different recording combinations





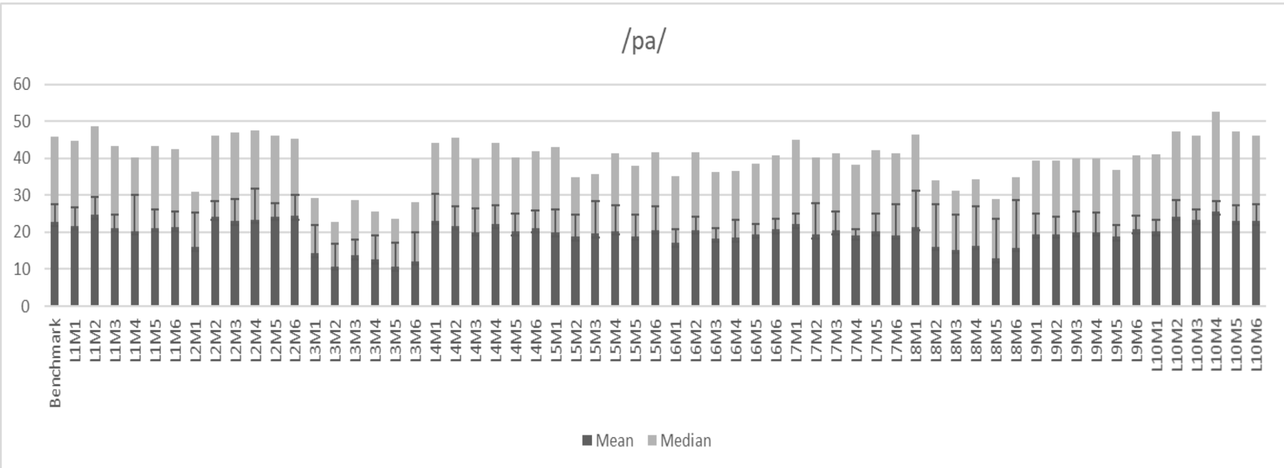
Non-parametric Friedman test was employed and there was a significant difference in formant frequencies between the benchmark system and the laptop configurations. Wilcoxon signed-ranks test was done to compare each of the L-M combinations with the benchmark system. The obtained data was then arranged manually and the L1-9-Mn (where 'n' indicates the microphone number from 1-6) combinations were found to have significant difference for most of the syllables. For all the eight syllables, L10-Mn combinations had no significant difference. Among the chosen L-Mn combinations, the combination which is most similar to that of the benchmark was found out manually by comparing the median values given in the Figures 3 & 4. It was found that the L10-M1, L10-M4 and L10-M6 combinations were closer to the benchmark system compared to other combinations.

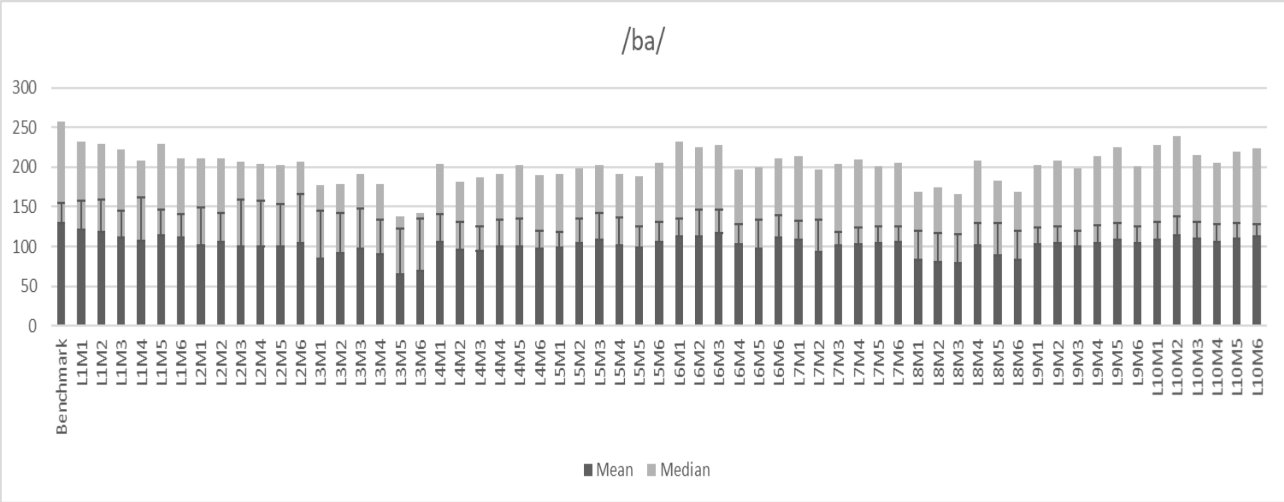
4.2.3 Effect of different laptop configurations, sound cards and microphones on VOT

The results of descriptive statistics are given in Figure 5 showing the mean, SD and median values of VOT for the different combinations and the benchmark system.

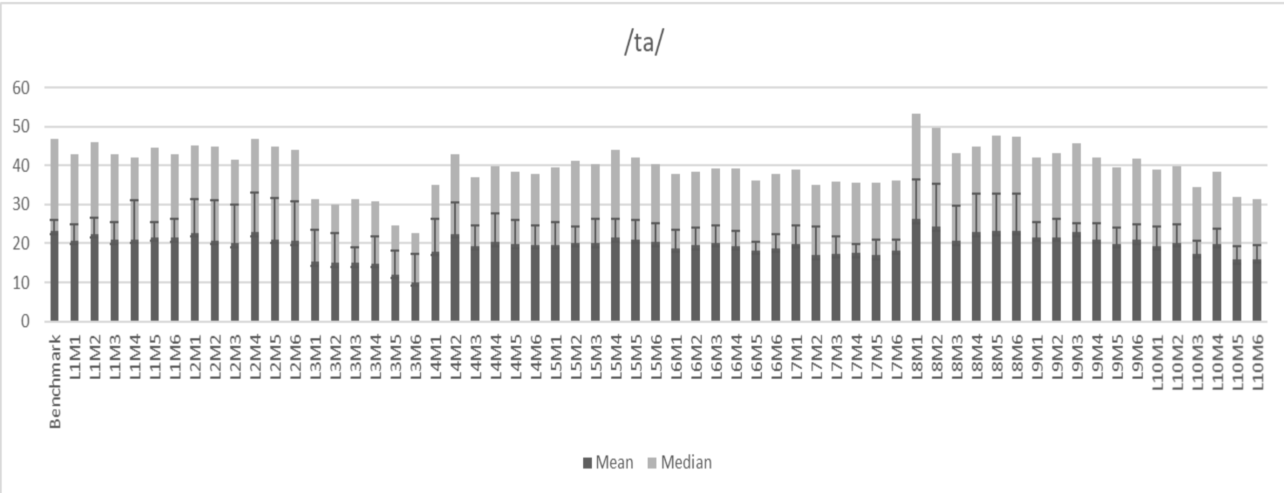
Figure 5

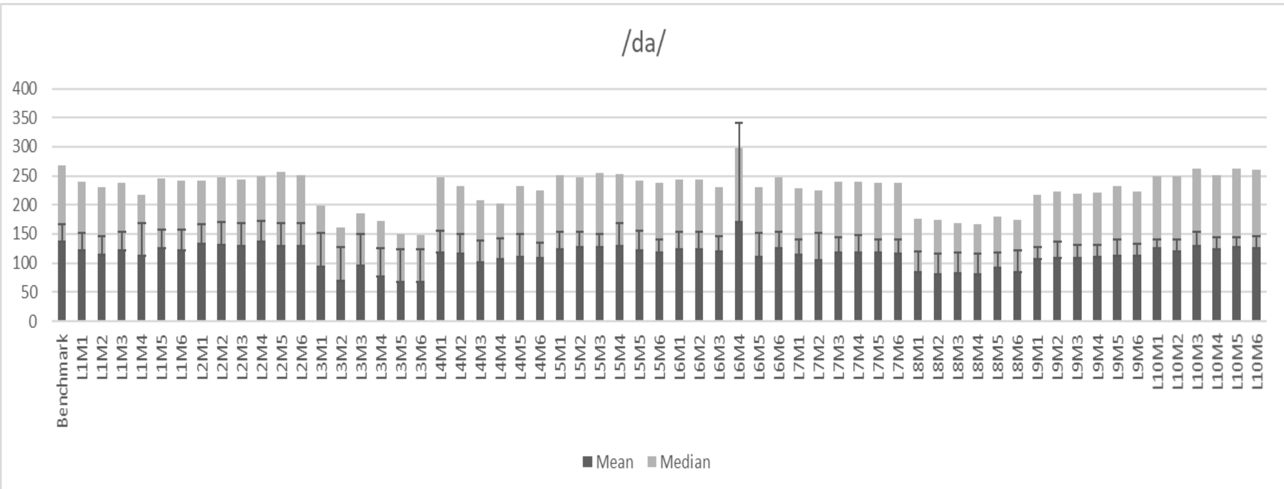
a. Mean, SD & median values of VOT (msec) for sounds /pa/ and /ba/ for different recording combinations



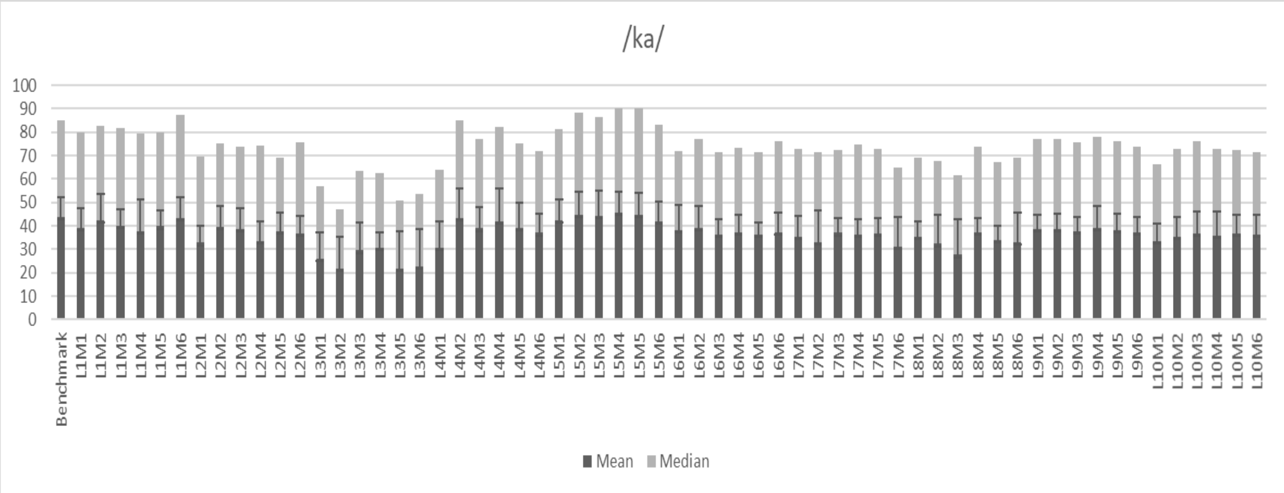


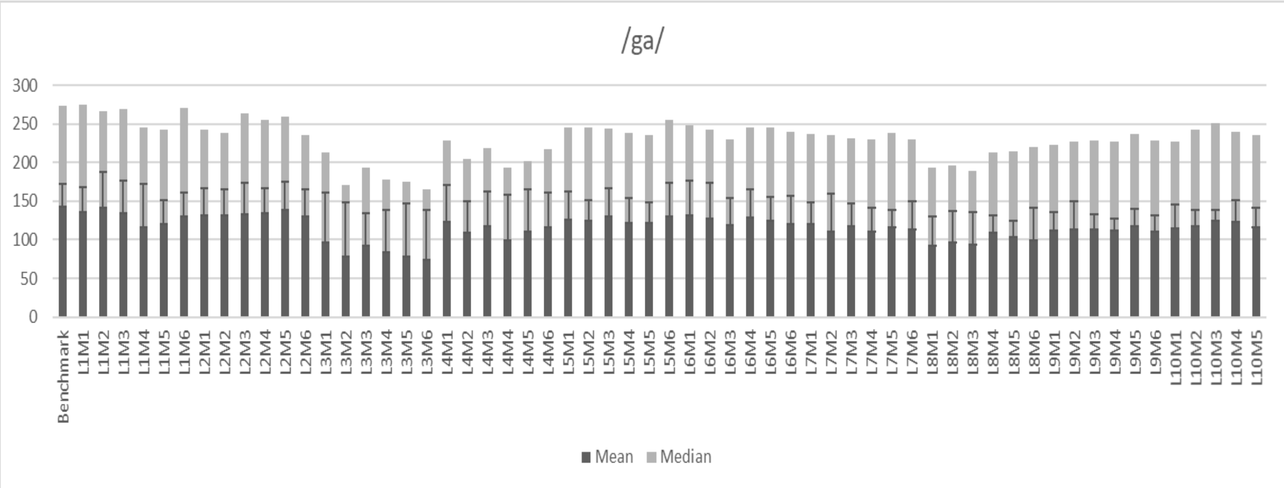
b. Mean, SD & median values of VOT (msec) for sounds /ta/ and /da/ for different recording combinations



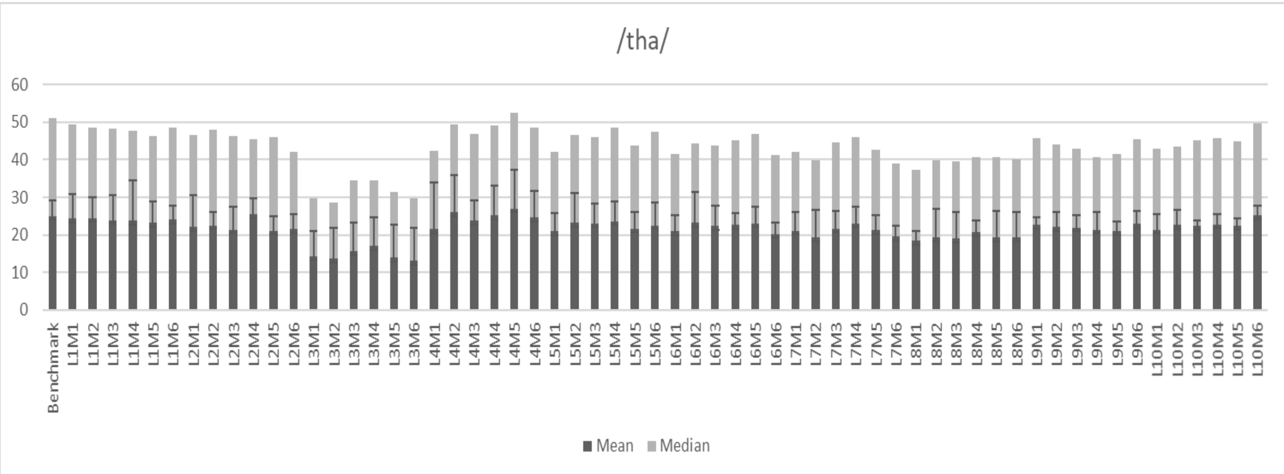


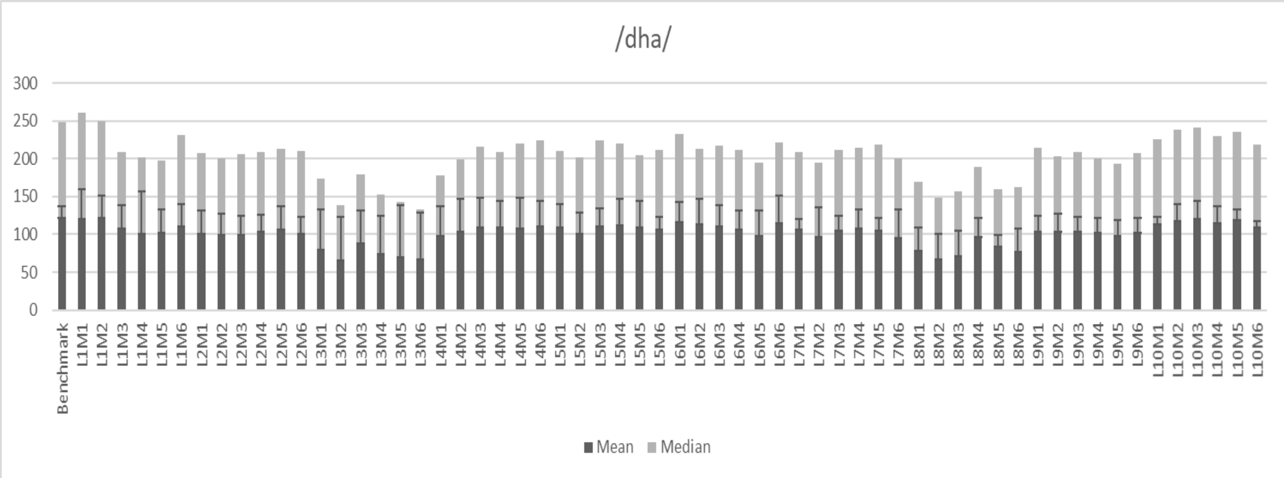
c.Mean, SD & median values of VOT (msec) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, SD & median values of VOT (msec) for sounds /tha/ and /dha/ for different recording combinations





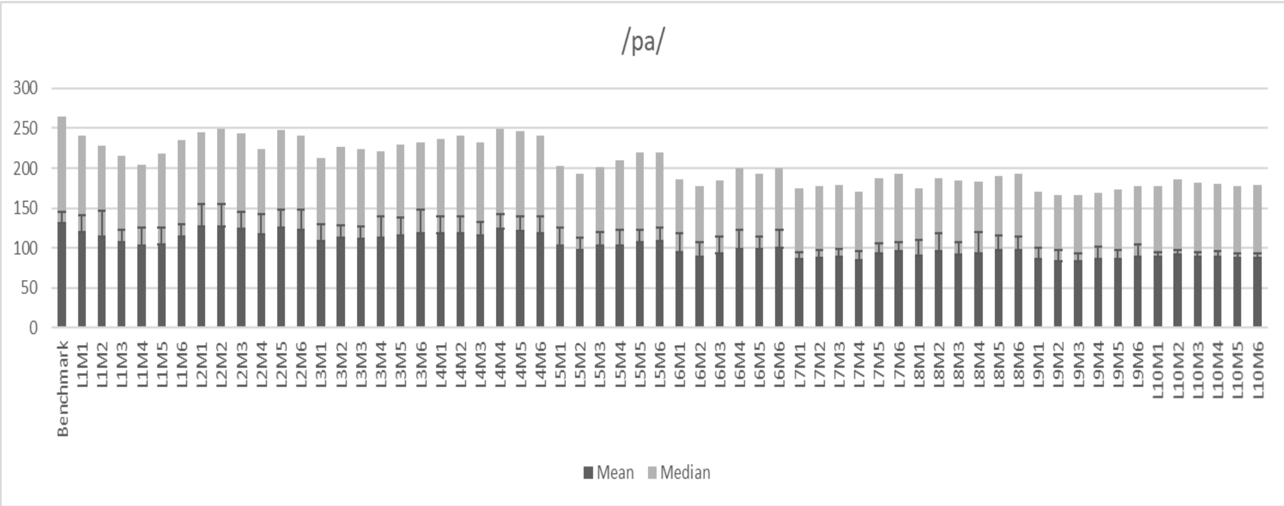
Friedman test revealed that there were significant differences between the L-M combinations compared to that of benchmark system, for most of the syllables. Wilcoxon signed-ranks test was done to compare each of the L-M combinations with the benchmark system. The obtained data was then arranged manually and the L1-Mn and L5-Mn combinations (where 'n' indicates the microphone number from 1-6) were found to have no significant difference for most of the consonants. Among the L-M combinations that had no significant differences, the combinations closer to that of the benchmark system was derived manually by comparing the median values. It was found that the L1-M1 and L5-M6 combinations performed closer to the benchmark system, in terms of VOT.

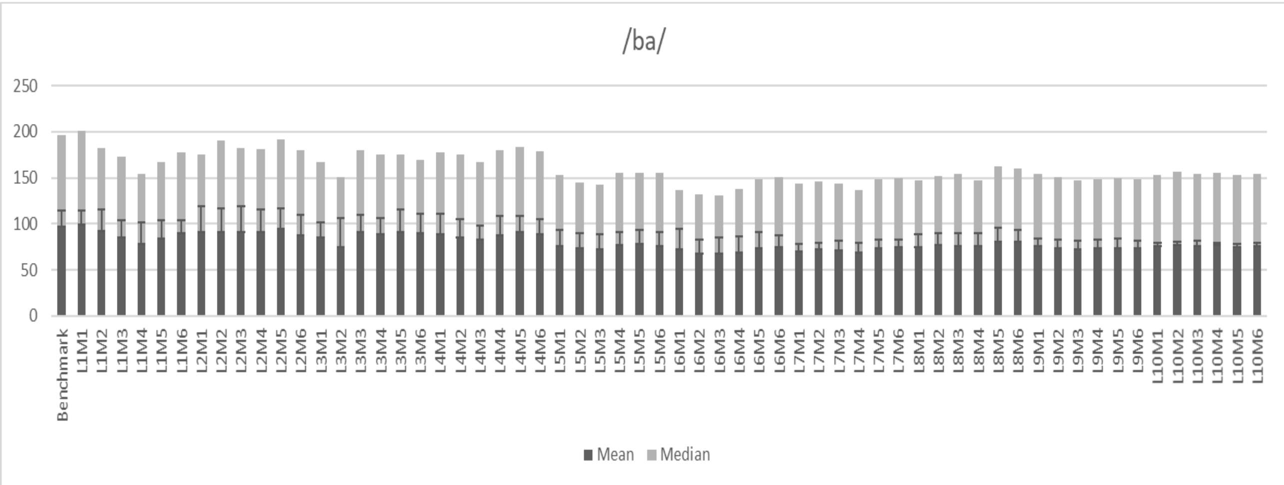
4.2.4 Effect of different laptop configurations, sound cards and microphones on closure duration

The mean, median and standard deviation of closure duration were calculated for all L-M combinations as well as for the benchmark system for each of the syllables and are shown in Figure 6.

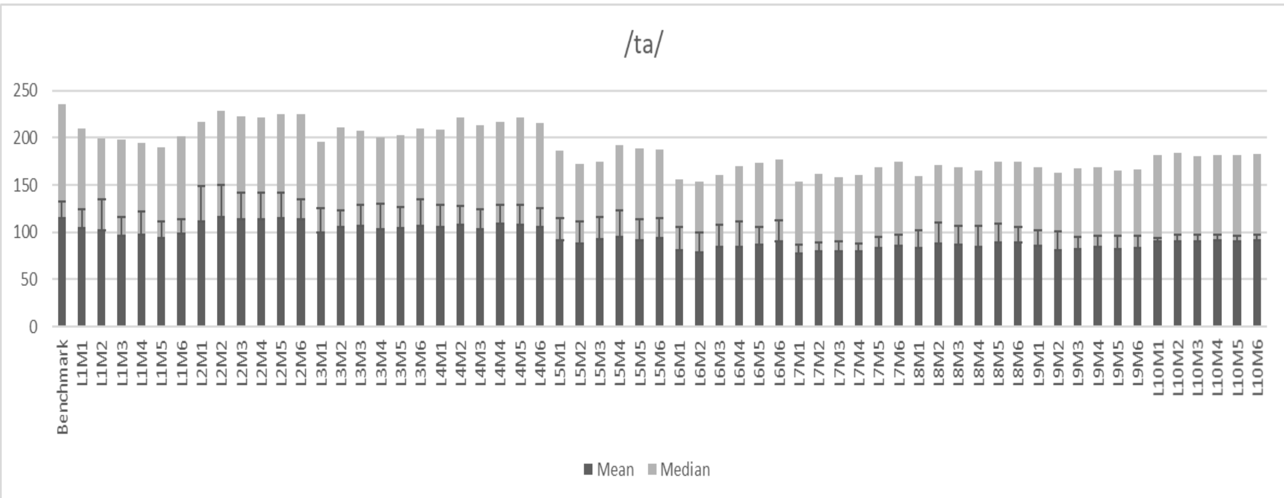
Figure 6

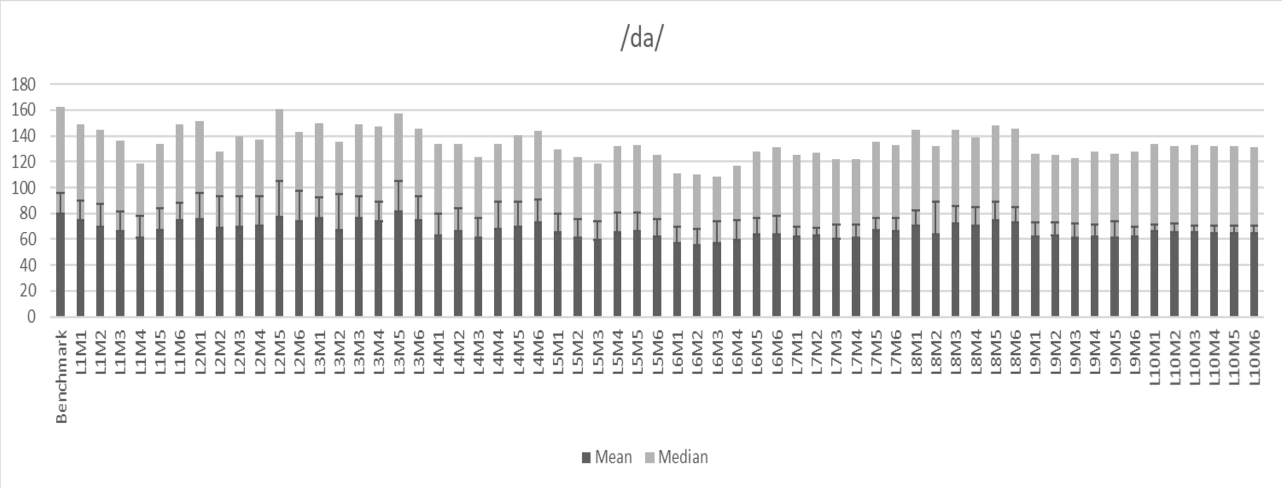
a. Mean, median and SD of closure duration (msec) for sounds /pa/ and /ba/ for different recording



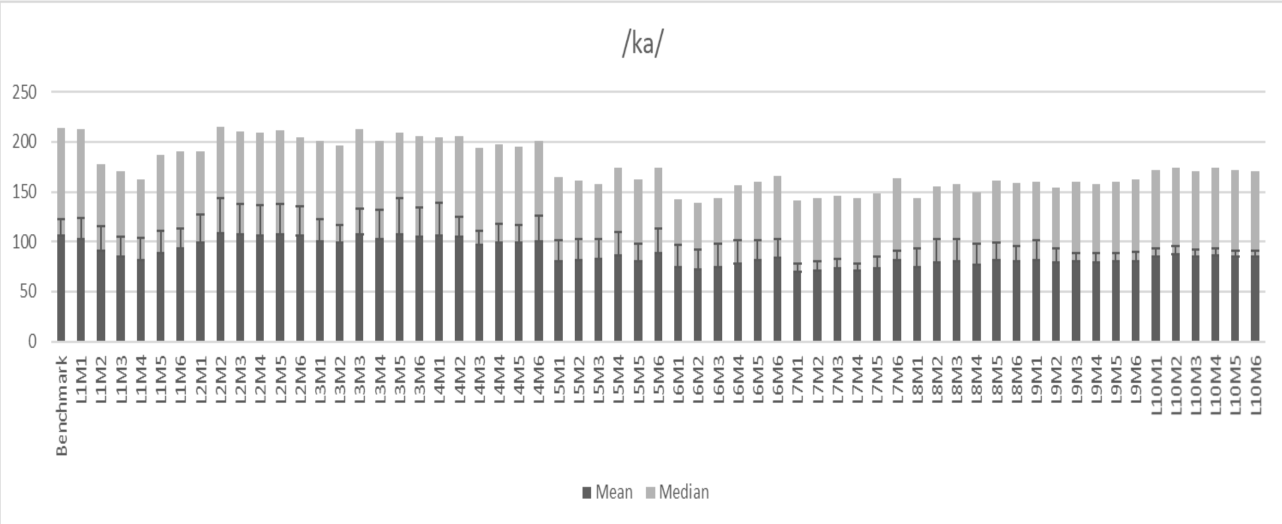


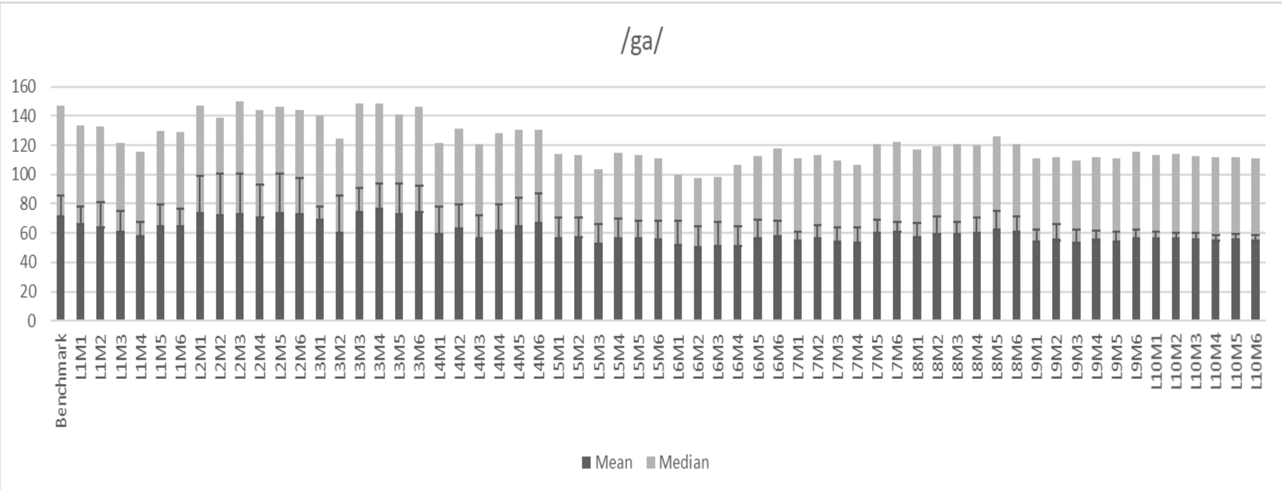
b. Mean, median & SD of closure duration (msec) for sounds /ta/ and /ba/ for different recording combinations



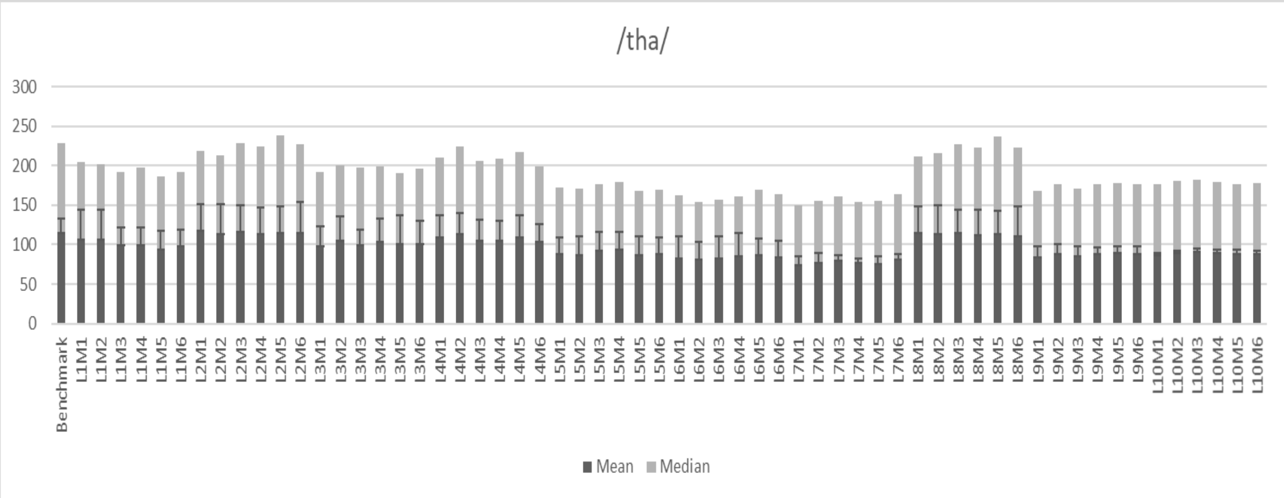


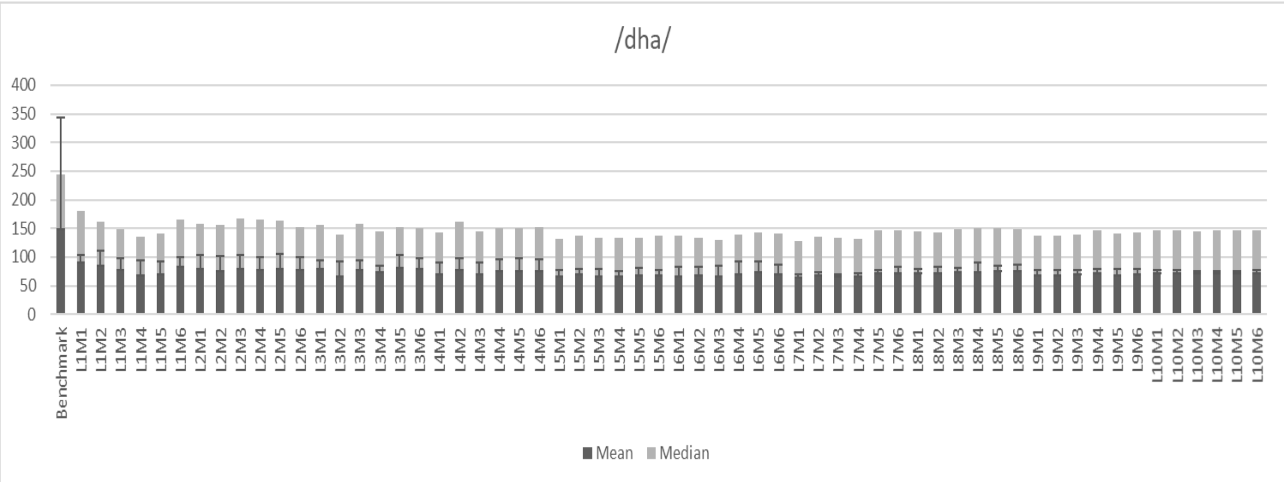
c. Mean, median and SD of closure duration (msec) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, median and SD of closure duration (msec) for sounds /tha/ and /dha/ for different recording combinations





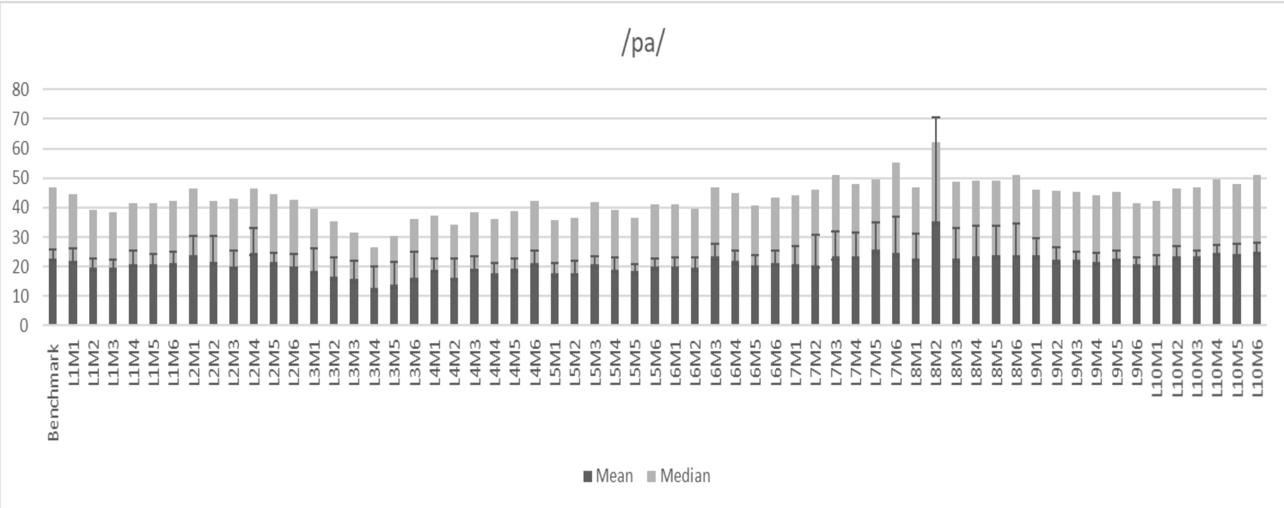
Non-parametric Friedman test was used and significant difference was observed for all the sounds. Wilcoxon signed-ranks test was done to compare each of the L-M combinations with the benchmark system. The obtained data was then arranged manually and the L1-Mn and L2-Mn (where ‘n’ indicates the microphone number from 1-6) combinations were found to have no significant difference for most of the syllables. Among the chosen L-Mn combinations, the combinations which were most similar to that of the benchmark system were manually compiled by comparing the median values (Figure 6). Accordingly, the L1-M1, L2-M2 and L2-M3 combinations were close to the benchmark system, in terms of closure duration.

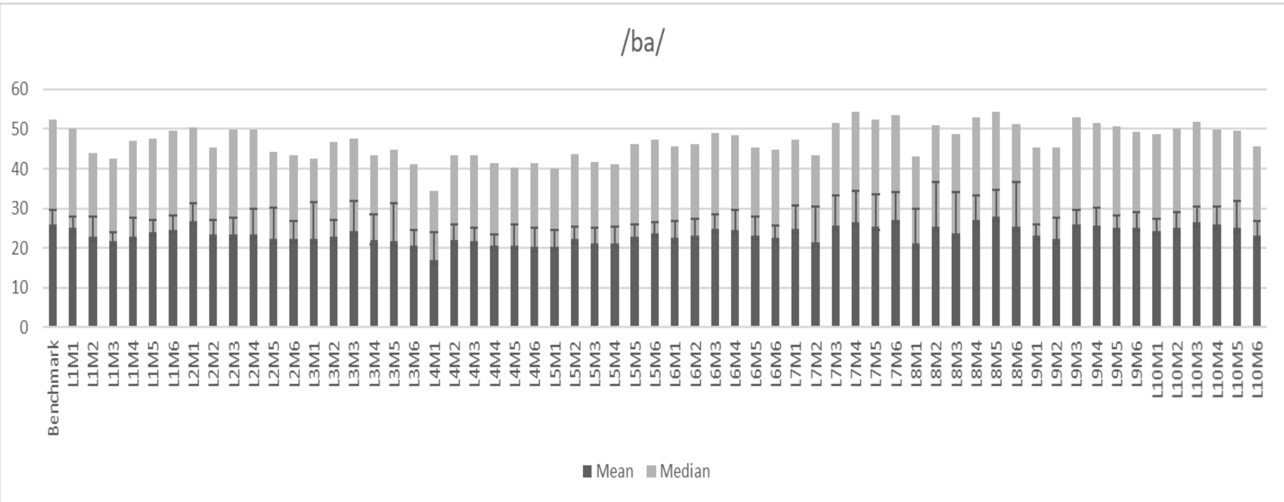
4.2.5 Effect of different laptop configurations, sound cards and microphones on transition duration

The mean, median and standard deviation of transition duration of each of the L-M configurations and the benchmark system for each of the syllables are shown in Figure 7.

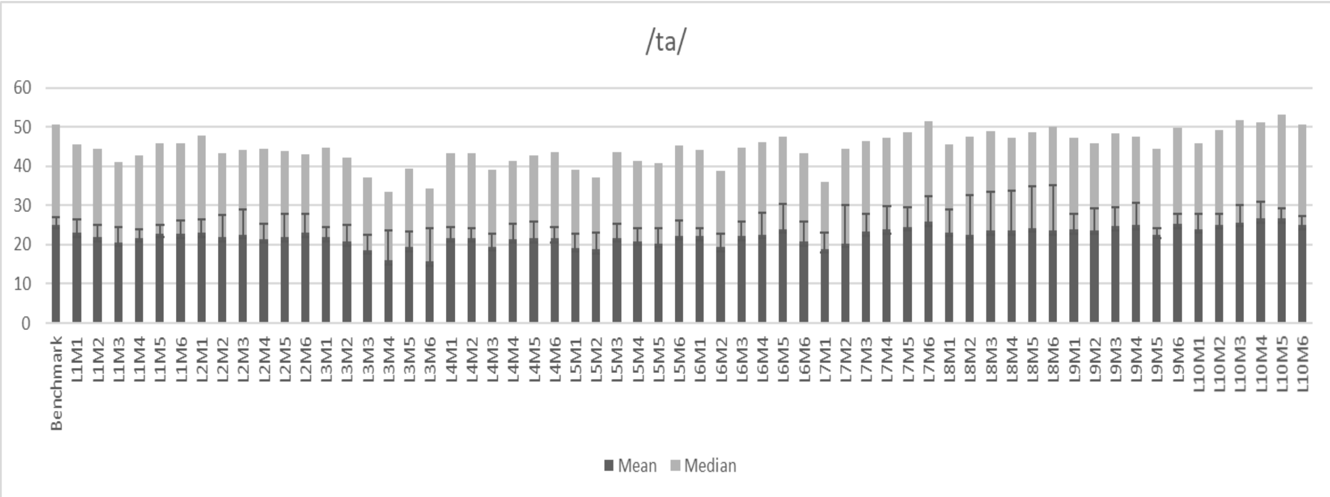
Figure 7

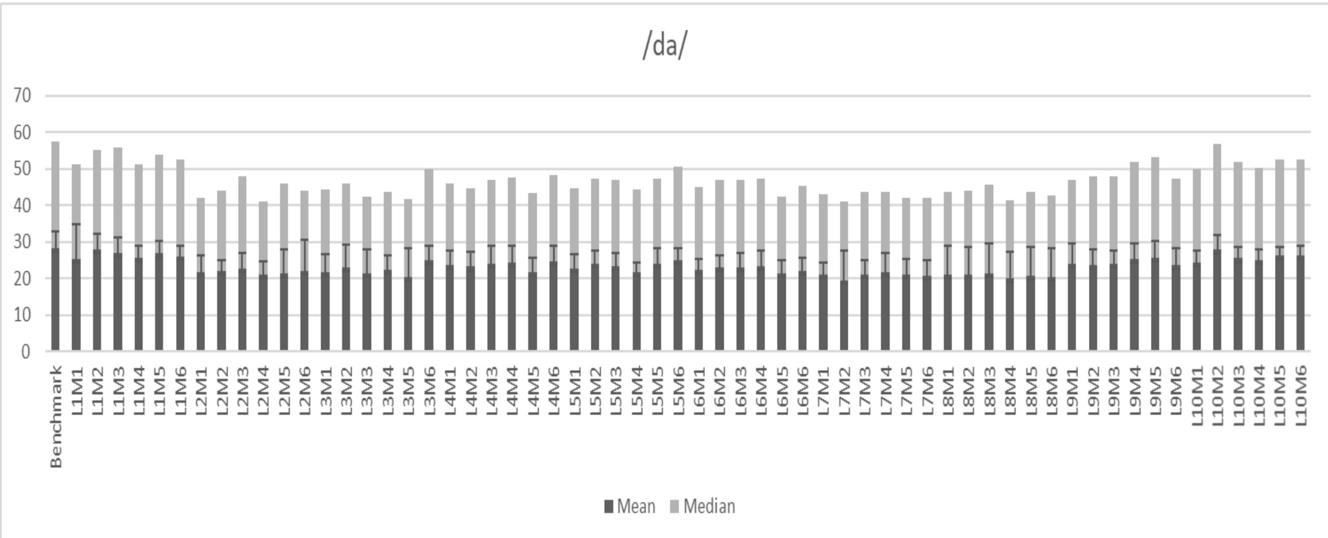
a. Mean, median and SD of transition duration (msec) for sounds /pa/ and /ba/ for different recording combinations



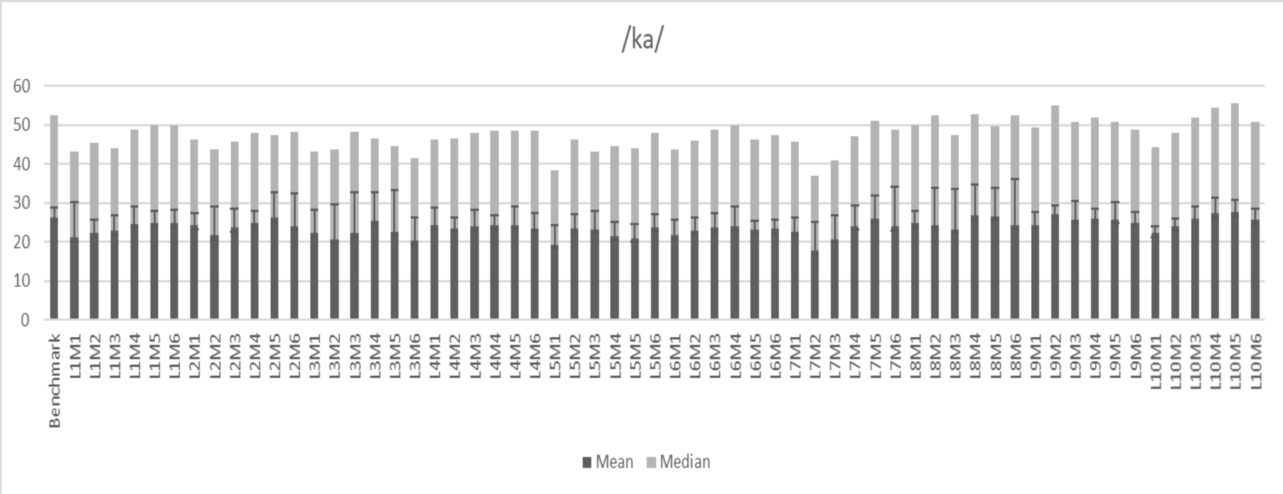


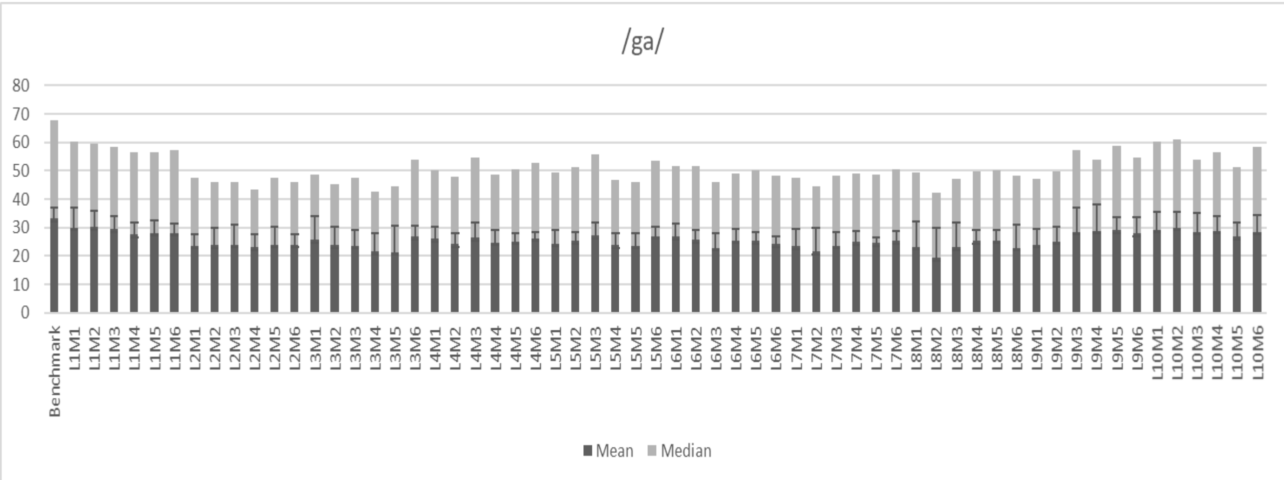
b. Mean, median and SD of transition duration (msec) for sounds /ta/ and /da/ for different recording combinations



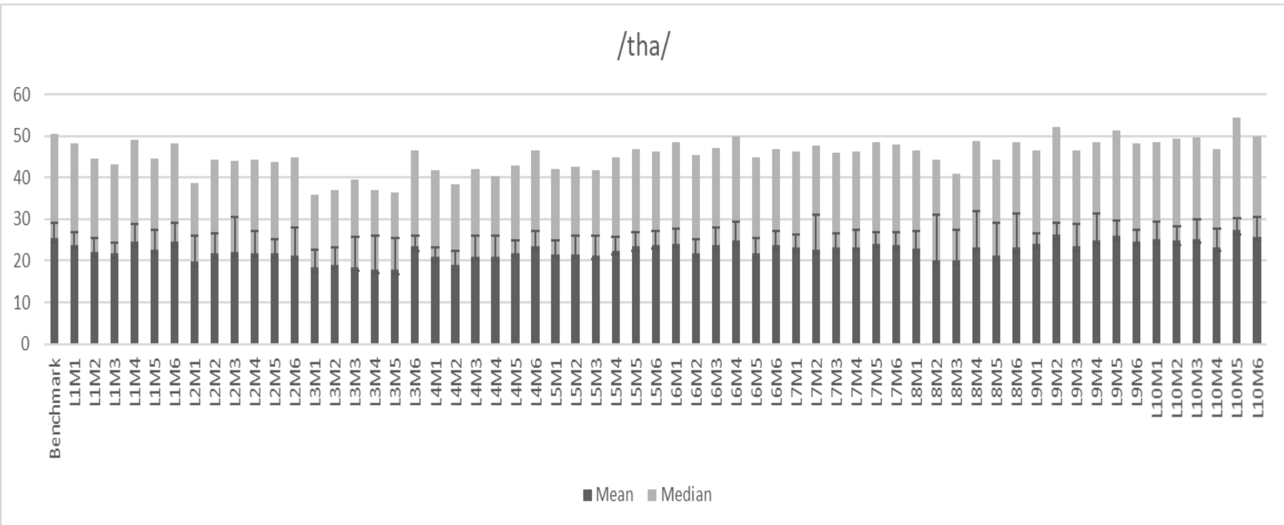


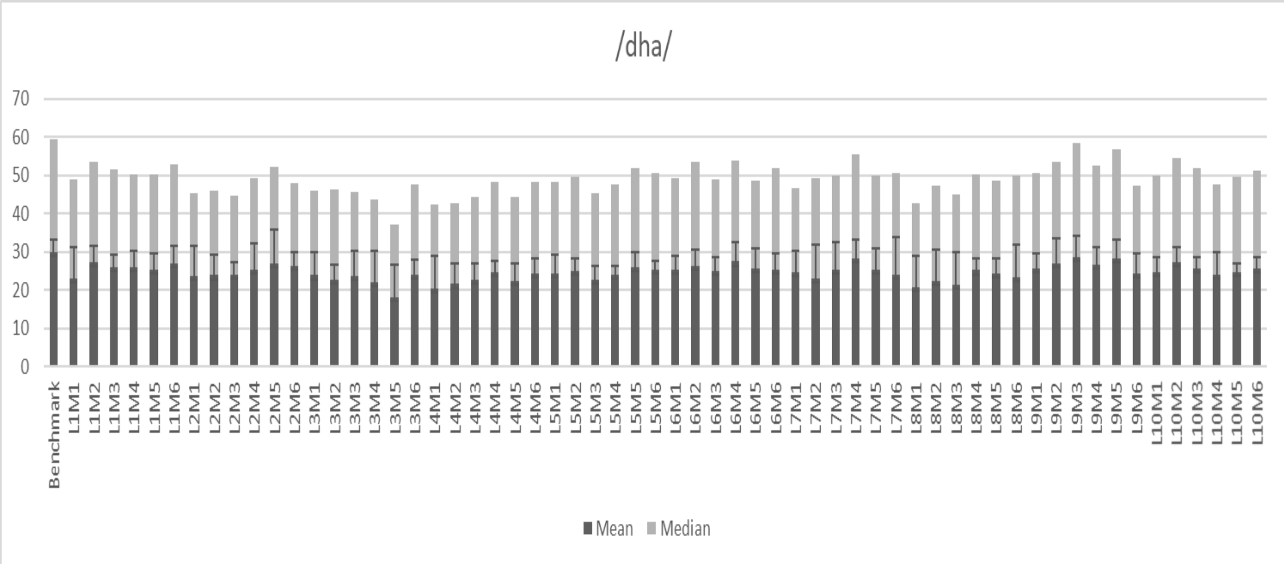
c. Mean, median and SD of transition duration (msec) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, median and SD of transition duration (msec) for sounds /tha/ and /dha/ for different recording combinations





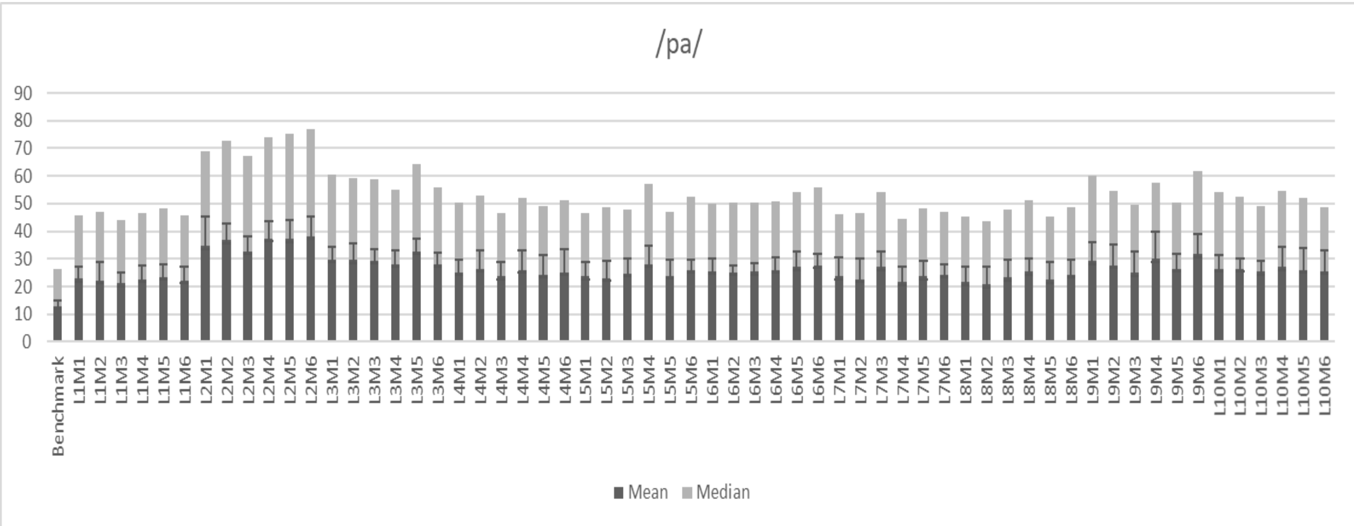
Non-parametric Friedman test was used and significant difference was observed for all the sounds. Wilcoxon signed-ranks test was done to compare each of the L-M combinations with the benchmark system. The obtained data was then arranged manually and the L1-Mn, L9-Mn and L10-Mn (where 'n' indicates the microphone number from 1-6) combinations were found to have no significant difference for most of the syllables. The LM combination which is least different compared to the benchmark system was found out manually by comparing the median values as shown in Figure 7. For the parameter transition duration, it was found that the L1-M1, L9-M5 and L10-M2 combinations were closer to the benchmark system in terms of transition duration.

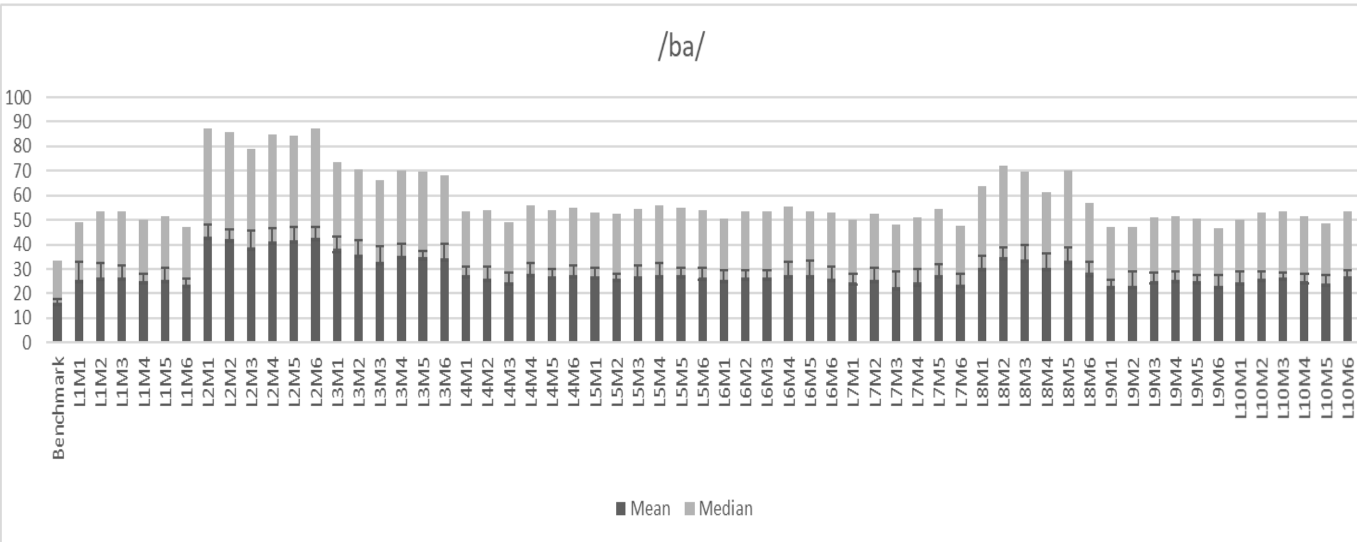
4.2.6 Effect of different laptop configurations, sound cards and microphones on spectral tilt

The mean, median and standard deviation of spectral tilt were calculated for all L-M combinations against that of the benchmark system for each of the syllables and are shown in Figure 8. Test for normality was carried out and the data did not fall in a normal distribution curve. Hence non-parametric tests were executed on the data.

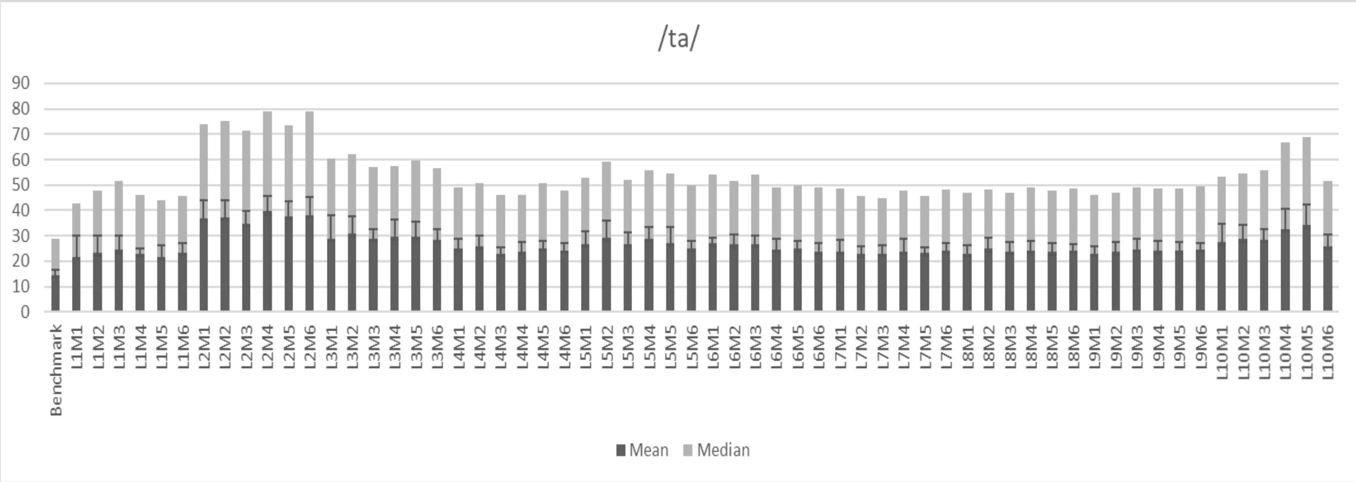
Figure 8

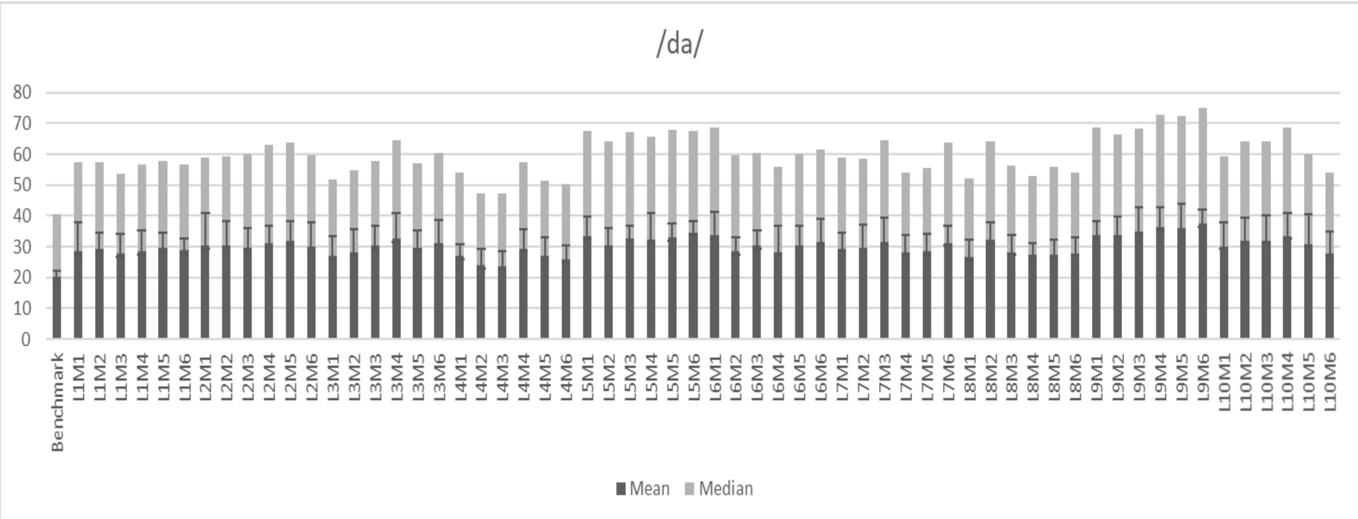
a. Mean, median and SD of spectral tilt (dB/Hz) for sounds /pa/ and /ba/ for different recording combinations



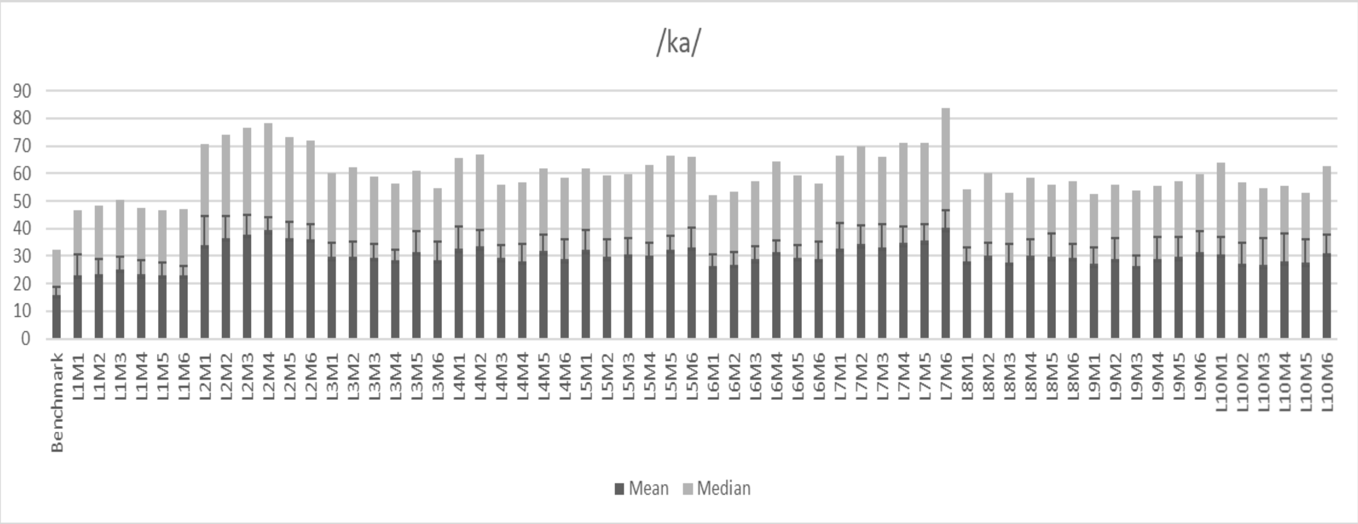


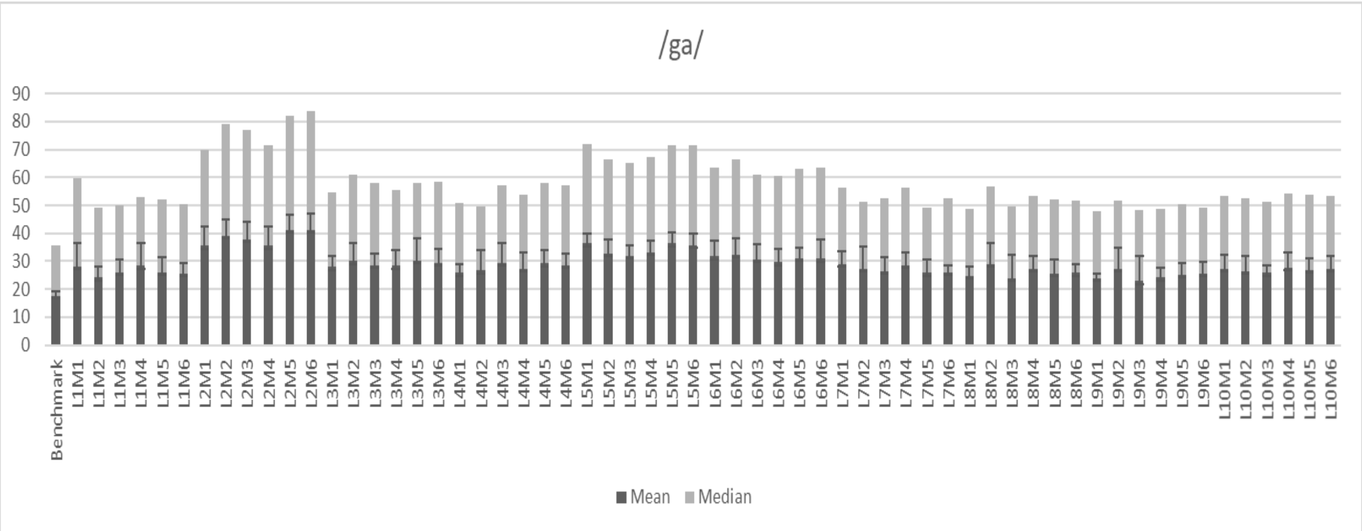
b. Mean, median and SD of spectral tilt (dB/Hz) for sounds /ta/ and /da/ for different recording combinations



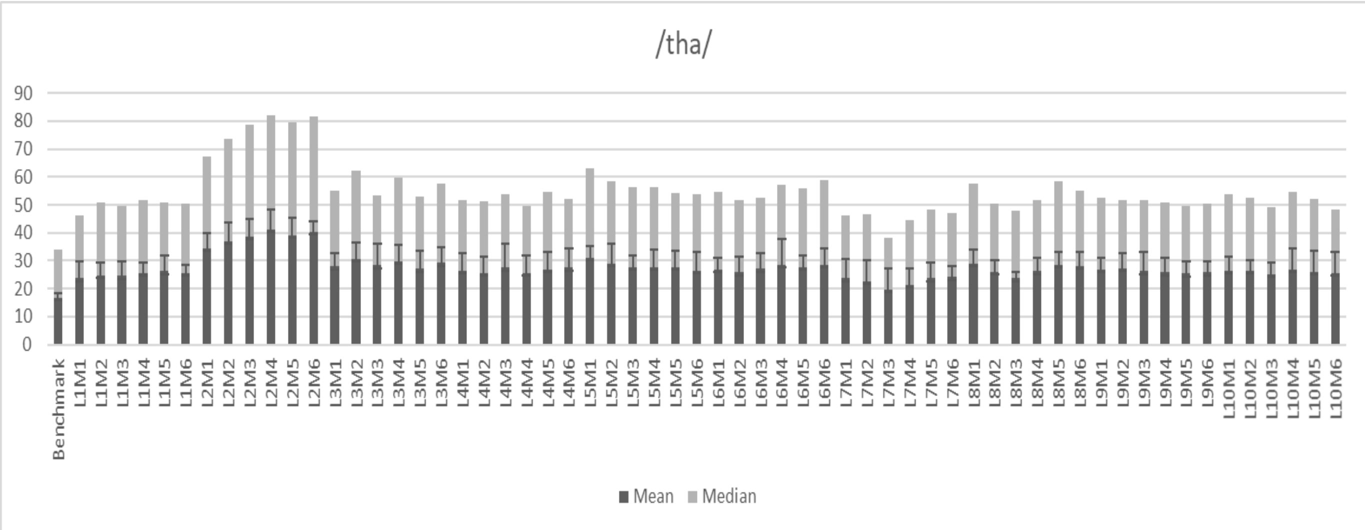


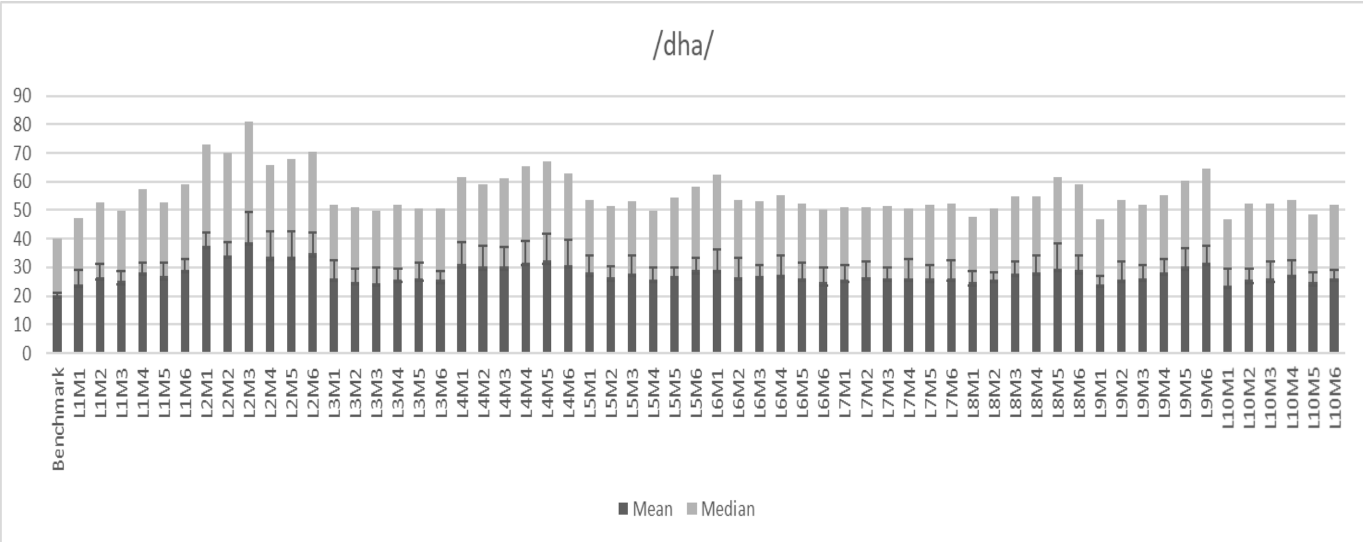
c. Mean, median and SD of spectral tilt (dB/Hz) for sounds /ka/ and /ga/ for different recording combinations





d. Mean, median and SD of spectral tilt (dB/Hz) for sounds /tha/ and /dha/ for different recording combinations





Non-parametric Friedman test was used and significant difference was observed for all the sounds. Wilcoxon signed-ranks test was done to compare each of the L-M combinations with the benchmark system. L1-Mn was found to be the combinations those were least deviant from the benchmark. Among the chosen L-Mn combinations, the combination which is closer to the benchmark was found out manually by comparing the median values. It was found that for spectral tilt, the L1-M1 combination was closer to the benchmark system.

4.3 Most affected parameter

Statistical analysis revealed that there was significant difference in all the parameters between the recordings from different L-M combinations and those from the benchmark system. Spectral tilt was found to be the most affected parameter as all the combinations showed a significant difference from benchmark as against the other parameters. Thus, spectral tilt could be concluded as the parameter that was maximum influenced by the recording combinations.

4.4 Effect of gender on the most significant factor - spectral tilt

A non-parametric Kruskal-Wallis test was conducted to evaluate differences among the gender on spectral tilt. The result revealed that there was no significant effect of gender on spectral tilt ($\chi2 = 0.11$, df = 1, $p = 0.73$). Thus, it may be concluded that there is no effect of gender on the most significant factor.

4.5 Cost effective configuration for optimal quality recording

The combination L1-M1 with specifications - Intel Core i7-4110 CPU 2.00 GHZ, with Windows 8.1, 64 bit OS and 4GB RAM with 24bit, 192000 Hz sound card and with built in microphone - was found to be closer to the benchmark system, for most of the parameters as shown in Table 3. This laptop configuration could be recommended as the cost effective and optimal system for recording of speech samples for analysis. It was also noted that L10-M1 combination was closest to the benchmark configuration for F0 and formant frequencies.

Table 3

Closest combination to the benchmark system for each parameter

Parameter	Combination closest to the benchmark configuration
Fundamental frequency	L10-M1, L3-M1
Formant frequencies	L10-M1, L10-M4, L10-M6
VOT	**L1-M1**, L5-M6

Closure duration	**L1-M1**, L2-M3, L2-M2
Transition duration	**L1-M1**, L9-M5, L10-M2
Spectral tilt	**L1-M1**

4.6 Validation of the identified configuration

The identified optimal configuration (L1-M1) was validated by recording speech samples of another group of six participants, which included three male and three female participants, and by comparing with the values of benchmark system. Non-parametric Friedman test revealed no significant difference in the values of formant frequencies, closure duration, transition duration and spectral tilt in comparison to the values of benchmark system. Mean, SD and median values of all the parameters obtained during validation are shown in Table 4, in comparison to the benchmark system.

Table 4

a. Mean, SD and median values of F0 (Hz) obtained during validation of L1-M1 combination

Sound	Benchmark			L1-M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	169.9	54.28	169	171.6	55.03	170
/ba/	167.3	48.95	159.5	167.5	47.76	160
/ta/	172.1	56.77	164	172.3	56.23	166
/da/	172.9	39.76	158.5	168.8	41.77	160.5
/ka/	172.3	56.14	167.5	174.7	54.85	167.5
/ga/	171.9	44.99	157.5	170.7	49.84	166.5
/tha/	166.8	69.61	164.5	168.4	61.76	165
/dha/	158.1	57.92	155	172.3	45.94	157.5

b. Mean, SD and median values of F1 (Hz) obtained during validation of L1-M1 combination

Sound	Benchmark			L1M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	741.00	73.522	725.00	722.30	44.560	727.50
/ba/	643.90	111.627	633.00	647.80	91.052	629.00
/ta/	750.30	124.258	760.00	747.40	78.762	758.50
/da/	675.90	45.759	670.00	680.10	97.343	667.50
/ka/	770.20	124.666	782.00	776.20	66.939	778.50
/ga/	676.10	77.648	655.50	655.90	58.081	654.00
/tha/	749.90	87.492	744.50	747.00	95.980	743.00
/dha/	661.70	65.308	662.00	669.50	60.202	669.00

c. Mean, SD and median values of F2 (Hz) obtained during validation of L1-M1 combination

Sound	Benchmark			L1M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	1381.20	82.362	1385.00	1397.80	147.484	1383.00
/ba/	1397.40	114.723	1406.50	1415.10	117.136	1401.50
/ta/	1498.10	117.198	1505.50	1525.70	89.922	1511.50
/da/	1669.00	133.941	1662.00	1607.30	129.813	1619.00
/ka/	1460.10	108.410	1478.00	1471.80	177.028	1474.50
/ga/	1477.80	145.079	1544.50	1534.70	143.004	1530.00
/tha/	1438.80	96.105	1460.00	1504.10	120.355	1468.50
/dha/	1533.60	205.752	1600.50	1589.80	103.388	1583.50

d. Mean, SD and median values of VOT (msec) obtained during validation of L1-M1 combination

Sound	Benchmark			L1M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	21.22	4.790	22	14.22	12.060	17
/ba/	115.11	22.161	124.00	114.33	20.463	118.00
/ta/	20.90	4.677	22.00	10.80	10.250	14.00
/da/	124.33	28.935	127.00	108.11	33.449	95.00
/ka/	37.50	13.938	42.00	21.90	15.538	29.00
/ga/	117.22	55.581	128.00	79.11	67.649	96.00
/tha/	24.60	7.043	24.00	12.00	8.576	14.50
/dha/	122.56	28.276	127.00	102.11	26.774	100.00

d. Mean, SD and median values of closure duration (msec) obtained during validation of L1-M1 combination

Sound	Benchmark			L1M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	124.80	17.887	124.50	119.00	21.323	118.00
/ba/	96.00	21.213	95.50	91.80	17.242	91.50
/ta/	109.20	19.915	112.00	104.30	20.045	109.00
/da/	75.20	13.653	73.00	70.30	19.038	70.00
/ka/	109.20	34.509	105.50	101.80	20.574	99.00
/ga/	71.70	21.334	72.50	64.80	16.123	68.00
/tha/	113.90	33.205	110.00	113.90	36.892	98.50
/dha/	90.70	12.544	89.50	79.70	26.663	84.00

e. Mean, SD and median values of transition duration (msec) obtained during validation of L1-M1 combination

Sound	Benchmark			L1M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	18.60	7.545	21.00	19.30	3.268	19.50
/ba/	24.60	3.658	25.00	22.50	4.378	23.00
/ta/	21.80	2.700	23.00	20.60	3.777	20.50
/da/	25.80	3.011	25.50	24.20	4.780	23.50
/ka/	24.78	3.528	25.00	24.44	2.455	24.00
/ga/	28.60	8.289	28.50	27.10	3.348	26.50
/tha/	23.70	4.296	23.50	21.90	2.961	21.00
/dha/	26.10	4.557	27.50	25.80	4.077	26.00

f. Mean, SD and median values of spectral tilt (dB/Hz) obtained during validation of L1-M1 combination

Sound	Benchmark			L1M1		
	Mean	SD	Median	Mean	SD	Median
/pa/	13.00	1.826	13.50	23.60	5.168	23.00
/ba/	16.40	1.350	17.00	23.80	2.300	23.50
/ta/	14.50	2.068	14.50	23.30	3.773	22.50
/da/	20.20	1.989	20.50	23.70	4.715	23.50
/ka/	16.00	2.708	16.50	23.00	4.546	23.50
/ga/	17.70	1.418	18.00	26.70	7.243	23.00
/tha/	16.90	1.287	17.00	23.70	6.993	22.50
/dha/	20.20	1.033	20.00	26.50	3.951	25.00

CHAPTER 5

Discussion

The present study attempted to answer the following questions:

- Is there any change in the values of acoustic parameters when speech samples are recorded with different laptop configurations, sound cards and microphones when compared with that of the same samples recorded by a benchmark system?
- If yes, which parameter is most affected?
- In which combination, the acoustic parameters are least deviant?
- Is there any effect of gender on the most affected parameter?
- Does the recording combination which has shown least deviation show the same performance for another set of recorded samples?

5.1 Change in values of acoustic parameters of the speech samples recorded with different laptop configurations, sound cards and microphones

The speech samples recorded through each of the L-M combinations were compared with the speech samples recorded through the benchmark system on the basis of the following acoustic parameters:- a. Fundamental frequency (F0), b. Formant frequencies (F1, F2), c. Voice Onset Time (VOT), d. Closure duration, e. Transition duration and f. Spectral tilt. Results indicated that, there were significant differences in the values of these parameters in most of the L-M combinations when compared with the benchmark system. It could thus be inferred that the recordings made from all the 60 different L-M combinations were deviant from that of the benchmark system for most of the syllables. The changes in values of each parameter are discussed in the following subsections.

5.1.1 Fundamental frequency

Samples recorded through majority of the 60 combinations considered in this study were showing significant difference in fundamental frequency when compared with the benchmark system. Combinations L3-Mn and L10-Mn (‘n’ indicates the microphone type) showed significant differences for four and three out of the eight syllables respectively. L1-Mn, L2-Mn and L4-9-Mn showed significant differences for all the eight syllables. Deliyski et al. (2005a) found that the recommended sampling frequency for acoustic voice analysis is above 26 kHz. Hence, the influence of sampling frequency on our results may be ruled out as the recordings from all the LM configurations were done at a sampling frequency of 44.1 kHz. Svec and Granqvist (2010), in their tutorial addressing the important characteristics of microphones for accurate measurement of speech, stated that the frequency range of microphone should be wide enough to capture the lowest frequency of interest. The lowest frequency component in speech is F0. Most of the microphones in the above combinations were having a frequency response starting at 300 Hz (Appendix 3). The microphone in the benchmark configuration has a bottom limit of 6.3 Hz in the frequency range.

Out of all L3-Mn and L10-Mn combinations, L3-M1 and L10-M1 combination showed the least variation with the benchmark system. L3-M1 combination included a laptop with a 24 bit sound card with sampling frequency of 88.2 kHz and its inbuilt microphone. The frequency response of the inbuilt microphone is from 200 Hz to 18000 Hz (Appendix 3). The better low frequency response of this microphone would have resulted in accurate representation of the fundamental frequency. L10-M1 combination included a laptop with a 16 bit sound card with sampling frequency of 44.1 kHz and its inbuilt microphone. The frequency response of the inbuilt microphone of L10 was from 100 Hz to 14 kHz (Appendix 3), which justifies for the better performance of this combination. These results comply with the observation of Deliyski et al. (2006) that data acquisition system was highly influential on fundamental frequency of the recorded samples.

5.1.2 Formant frequencies

Majority of the 60 combinations were showing significant difference in formant frequencies of the recorded samples when compared with the benchmark system. Combinations L1-Mn, L2-Mn, L3-Mn, L4-Mn, L5-Mn, L6-Mn, L7-Mn, L8-Mn and L9-Mn were found to have significant deviations in the values of F1 and F2. Livijn (2004) found that frequency resolutions of the recording media will be influenced by the transfer functions of the constituents of the recording system. Significant difference in the formant frequencies in the recorded samples of L1-9-Mn could be due to the difference in the transfer function of these combinations compared to the benchmark system.

For majority of the syllables, L10-Mn combinations were found to have no significant difference in the formant frequencies. Out of all these combinations, L10-M1, L10-M4 and L10-M6 combinations showed the least variation with the benchmark system. L10-M1 combination included a laptop with core i3-M processor a 16 bit sound card with sampling frequency of 44.1 kHz and used inbuilt microphone of the laptop. L10-M4 combination used i-ball rocky microphone. L10-M6 used creative HS 720 microphone (Appendix 3). Deliyski et al. (2005b) recommended a sampling rate of 26 kHz and above for accurate and reliable acoustic analysis. The sound cards in all the three combinations which showed minimum deviations of formant frequencies in our study were using a sampling frequency above 26 kHz. Parsa et al. (2001) probed the effect of the type of microphone on acoustic measures and found that, condenser microphone produced least variations the frequency spectrum of the speech signal. The microphones M1, M4 and M6 used in our study were condenser microphones and hence, their combinations with laptops with sampling frequency above the optimal values must have resulted in reduced variation in the formant frequencies.

5.1.3 Voice Onset Time (VOT)

Most of the 60 combinations considered in this study were showing significant difference in VOT of the recorded samples when compared with the benchmark system. Combinations L2-Mn, L3-Mn, L4-Mn, L6-Mn, L7-Mn, L8-Mn, L9-Mn and L10-Mn were found to have significant deviations in the values of VOT. Livijn (2004) reported that different components of the recording system will have different transfer functions and different frequency resolution. This difference of frequency resolution in different components may lead to loss of spectral contrast (Schaub, 2008). Loss of spectral contrast may lead to smoothening of the temporal envelop. Turner et al. (1992) and Vander Horst et al. (1999) reported that temporal cues in stop consonants will be significantly affected by changes in the smoothness of the temporal envelop. This may be the reason for variation in VOT across different combinations of recording in this study.

Combinations L1-Mn and L5-Mn were found to have no significant difference for most of the consonants, whereas L1-M1 and L5-M6 showed the least variation in VOT for majority of the syllables. It may be interpreted that combinations L1-M1 and L5-M6, which showed the least variation in VOT, may be having reduced loss of spectral contrast. L5-M6 combination has a high end microphone (creative HS 720) which has good frequency response. Influence of recording microphone on the frequency spectrum of the voice signal was reported by Parsa et al. (2001). Similarly, M1, the inbuilt microphone of laptop L1, has also got a good frequency response.

5.1.4 Closure duration

For the parameter closure duration, samples recorded through majority of the 60 combinations were showing significant difference when compared with the benchmark system. Combinations L3-10-Mn were found to have significant deviations in the values of closure duration. Modification of the temporal envelop due to loss of spectral contrast resulting from different frequency resolutions of the constituents of the recording system may be contributing to the variation in closure duration.

Combinations L1-Mn and L2-Mn were found to have no significant difference for most of the consonants, whereas combinations L1-M1, L2-M2 and L2-M3 showed the least variation in closure duration in comparison with the benchmark system. The good sound card of L1 and the better features of the inbuilt microphone M1 must have resulted in better frequency resolution and thus reduced modification of the temporal envelop. L2 also has a sound card with good features, which in combination with the better quality microphones M2 and M3 must have helped L2-M2 and L2-M3 combination to have less variation in closure duration.

5.1.5 Transition duration

With respect to transition duration, samples recorded through majority of the 60 combinations were having significant difference when compared with the benchmark system. Combinations L2-Mn, L3-Mn, L4-Mn, L5-Mn, L6-Mn, L7-Mn and L8-Mn were found to have significant deviations in the values of transition duration. As in the case of closure duration, modification of the temporal envelop due to loss of spectral contrast resulting from different frequency resolutions of the constituents of the recording system may be contributing to the variation in closure duration.

Combinations L1-Mn, L9-Mn and L10-Mn were found to have no significant difference for most of the consonants, whereas the combinations L1-M1, L9-M5 and L10-M2 were closer to the benchmark system. For L1-M1 combination, the factors responsible for better performance are the same as explained under the sub-heading ‘Closure duration’. Better performance of L9-M5 may be due to the higher processor speed (2.53 GHz) of L9. Better performance of L10-M2 may be because of the better sensitivity of microphone M2.

5.1.6 Spectral tilt

For spectral tilt, samples recorded through majority of the 60 combinations were having significant difference when compared with the benchmark system. Combinations L2-Mn, L3-Mn, L4-Mn, L5-Mn, L6-Mn, L7-Mn, L8-Mn, L9-Mn and L10-Mn were found to have significant deviations in the values of spectral tilt. Spectral tilt is estimated as the slope of the least squares linear fit to the log power spectrum of the speech signal (Enflo, 2009). It shows the distortion observed in the spectrum when the speech signal is passed through a linear time-invariant filter. The recording combinations used in the present study can be approximated to a linear time-invariant filter. Each combination will have a different transfer function for this filter (Livijn, 2004), which may be inducing different levels of distortion in the spectrum. This could be the reason for variation in spectral tilt values of each of these combinations.

Combination L1-Mn were found to have no significant difference for most of the consonants, whereas the configuration which is closer to the benchmark system was found to be the L1-M1 combination. The better performance of L1-M1 combination may be attributed to the higher sampling rate, high speed processor, 64 bit operating system as well as the good quality inbuilt microphone.

5.2 Most significant factor influenced while recording

Vogel and Morgan (2009) commented that the quality of recording is influenced by some acoustic measures more compared to others. For all the syllable conditions, the spectral tilt values for most of the L-M combinations were found to be significantly altered when compared with the benchmark system. Spectral integrity refers to fine spectral information contained in a speech signal. Constituents of the recording combination will have different transfer functions which may disturb the spectral integrity of a speech signal leading to continuous spectral distortion (O'Brien, 2002). Jokinen and Alku (2017) while estimating the spectral tilt of the glottal source from telephone speech using a deep neural network, observed that the spectral tilt of telephonic speech is deviant from natural speech. Jokinen et al. (2014) proposed that intelligibility of narrowband telephone speech can be improved by adjusting the spectral tilt. These findings of the previous researchers indicate that spectral tilt gets modified when the speech gets processed through a microphone followed by a processing system. Our conclusion stating spectral tilt as the parameter which is more affected while recording with different combinations is in tune with the findings of the previous researchers. Thus, spectral tilt is a good indicator of the quality of recording of any speech sample.

5.3 Effect of gender on spectral tilt

No effect of gender was observed on the variations in the values of spectral tilt. This was expected as gender will not play any role in the deviation of spectral tilt. Deliyski et al. (2006) observed that gender were highly influential on measurements of jitter and shimmer. As discussed above, the deviations in spectral tilt in most of the recording combinations were mainly due to the different transfer functions of the constituents of the recording system which will not be influenced by the gender.

5.4 Optimal laptop-microphone combination for recording of speech samples

L1-M1 combination had least deviations in the values of VOT, closure duration, transition duration and spectral tilt in comparison with the benchmark system. This could be possibly attributed to the components of the recording system of this configuration. This is in accordance to the study done by Livijin et al. (2004) who reported that frequency resolution of the recording media will be influenced by the transfer function of the constituents of the recording system. Laptop L1 had a higher end sound card with AD 1984 codec. The reasonably good characteristics of the inbuilt microphone must have also contributed to the better performance of this combination (Appendix 3). The sound cards and microphones of all other combinations were inferior to the L1-M1 combination.

The selection of optimal configuration may also depend on the acoustic measures which the investigator is looking into (Vogel & Morgan, 2009). The L10-M1 combination was found to be optimal for parameters such as fundamental frequency and formant frequencies.

Microphone is considered as the most important feature in the speech recording process (Deliyski et al., 2005). Specifications of the microphone greatly influence the quality of the recorded speech (Vogel & Morgan, 2009). Titze & Winholtz (1993) examined the effect of characteristics of the microphone on the recorded speech quality and found that the sensitivity of the microphone was the factor with maximum sensitivity of -60 dB is essential for accurate acquisition. The M1 microphone which is a constituent of L1-M1 combination has a sensitivity of above -60 dB (Appendix 3). Similarly the M1 microphone in the L10-M1 combination also has a sensitivity of above -60 dB (Appendix 3). Parsa et al. (2001) observed that the frequency response is another influential factor which modifies the acoustic signal during recording. For the microphone to be equally sensitive to all frequencies, the frequency response should be flat for the speech frequency range (Carson et al., 2003; Hillenbrand, 2011). Microphone of laptop L1 and microphone of laptop L10 has a flat frequency response from 100 Hz to 15000 Hz.

5.5 Cost effectiveness of the optimal combination

It is difficult to suggest an optimal system for speech acquisition (Vogel & Morgan, 2009). Practical issues such as cost, portability etc must be considered. The highest quality recording system would be the stand-alone digital recorder as identified by Vogel & Morgan, 2009, but would be expensive. L1-M1 combination which was identified as the optimal combination is cost effective also, as this combination used the inbuilt microphone in the laptop. This combination is cost effective in comparison to the high-quality recorder coupled with a condenser microphone which was identified as the optimal configuration by Vogel et al. (2015). The cost effectiveness may also be considered by the fact that the laptop can be used for other purposes also where as the high quality recorder coupled with a condenser microphone can be used only for recording purposes.

5.6 Validation of the optimal combination

The identified optimal configuration was validated with the recorded speech samples of another group of six participants. The L1-M1 combination was close to the benchmark system with respect to VOT, transition duration, closure duration and spectral tilt, even in the newly recorded samples.

CHAPTER 6

Summary and Conclusions

The purpose of this study was to identify an optimal configuration for recording of speech samples for acoustic analysis of voice and speech. The study investigated the effect of combinations of different laptop configurations, sound cards and microphones on the fundamental frequency, formant frequencies, voice onset time, closure duration, transition duration and spectral tilt of the recorded speech samples in comparison to a benchmark system. The study also investigated the most significant parameter, the effect of gender on the most significant parameter. Validation of the identified configuration was done with speech samples recorded from different group of subjects.

In this study, an analysis of the extent to which acoustic parameters such as fundamental frequency, formant frequencies, voice onset time, closure duration, transition duration and spectral tilt of the recorded speech samples were deviating with reference to a benchmark system was carried out. The value of each parameter was noted from each of the eight syllables recorded by each of the sixty combinations as well as from the syllables recorded by the benchmark system. Thus, a total of 61 Nos. x 8 stimuli = 488 Nos, 488 Nos. x 10 subjects = 4880 x 2 utterances = 9760 speech samples were recorded and analyzed. The combination closest to the benchmark system for each parameter was found out. The optimal configuration for recording of speech samples was found by identifying the combination closest to the benchmark system in majority of the parameters.

6.1 Important results of the study

The important findings of the study are summarized below:-

- Values of parameters such as fundamental frequency, formant frequencies, voice onset time, closure duration, transition duration and spectral tilt of the speech samples change, in comparison to a benchmark system, when recorded with different combinations of laptop configurations, sound cards and microphones.

- For each parameter, some of the combinations did not produce significant change, when compared with the benchmark system.
- For spectral tilt, samples recorded by all the combinations produced significant change, when compared with the benchmark system.
- The extent of deviation was higher in spectral tilt compared to all other parameters. Thus, spectral tilt was identified as the parameter which is most affected during recording.
- The L1-M1 combination which did not produce significant change in most of the parameters was identified as the optimal combination.

6.2 Implications of the study

- The results of the present study will help clinicians and researchers to utilize the optimal configuration suiting their needs.
- The study indicated the significance of each component of the recording system in bringing the recordings of speech samples closer to natural speech.
- Spectral tilt was identified as the parameter which is most affected during recording. This indicates that if the recorded samples have to be used for spectral analysis, then a high end recording system similar to the benchmark system should be preferred.
- For VOT, closure duration and transition duration, L1-M1 combination was found to be closer to the benchmark system. This indicates that if the recorded samples have to be used for analysis of temporal parameters, L1-M1 combination may be preferred.

6.3 Limitations of the present study

- Only stop consonants were included in the present study as stimuli. This restricts the scope of the obtained results to a specific group of speech syllables.

- All the parameters were measured manually and therefore, an error cannot be ruled out. If these procedures can be automated, then the study will be more accurate.
- The study considered 10 laptop configurations, which were easily available at the time of the study. All these configurations were in the price range of Rs. 40,000 to Rs. 60,000. This price range was selected to find an optimal combination within an affordable price. Laptops with better configuration may show better performance.

6.4 Future recommendations

- While comparing the performance of different combinations, it was found that the parameters of the sound card, sensitivity, frequency response and dynamic range of the microphones used are influencing the quality of recording. Future research can explore the effect of each of these parameters on recording.
- The study was purely objective in nature, considering only the values of parameters to identify the optimal configuration. Future studies can add perceptual experiments to find out whether the change in values of parameters affects the speech identification scores.
- Future research can extend this work to the latest configurations of laptops and microphones.

6.5 Significance of the results of the study

The significance of the results of the present study should be seen in the following context:

Many attempts have been made in the past to identify and compare the factors affecting the quality of sound recording. But none of these researchers have arrived at an easily affordable combination of recording components which would result in an optimum recording. The present study identified a cost effective configuration for optimal recording of speech samples for speech analysis. The optimal combination identified in the study will be a user friendly, widely available and cost effective alternative technology for acoustic analysis of voice and speech. The study also brought out the fact that if the samples are to be used for analysis of spectral parameters, then a high end recording system should be preferred.

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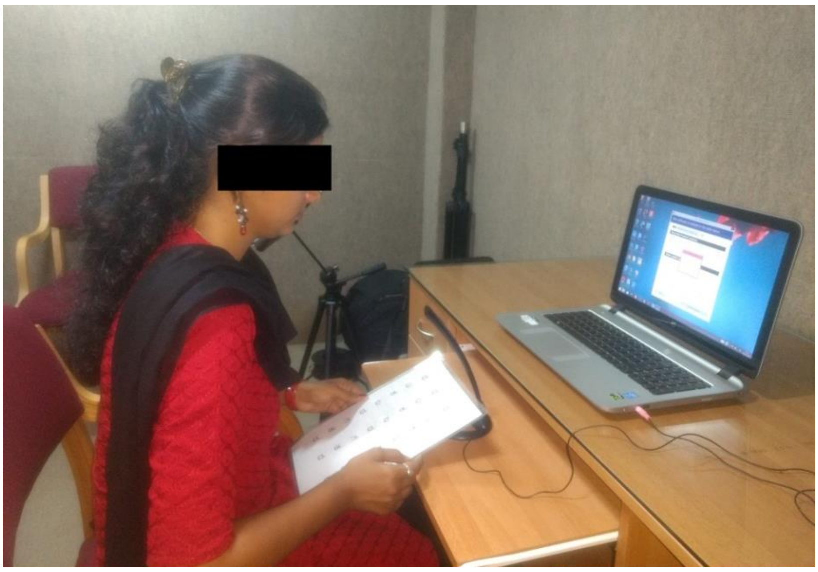
Recording procedure

Benchmark system

L-M configuration



APPENDIX – 2

Tables showing values of parameters in different LM combinations for different speech sounds

Table 5

a. Mean, SD & median values of F0 (Hz) for sounds /pa/ and /ba/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/pa/	Benchmark	167.3	56.65	159	/ba/	Benchmark	165.8	53.03	157
	L1-M1	169.9	54.28	169		L1-M1	169.2	48.94	166.5
	L1-M2	170.4	53.69	166.5		L1-M2	165.4	50.26	157
	L1-M3	172.9	55.01	167.5		L1-M3	167	49.72	162
	L1-M4	172.1	53.79	167.5		L1-M4	167.5	47.76	160
	L1-M5	170.1	53.59	166.5		L1-M5	167.3	48.95	159.5
	L1-M6	171.6	55.03	159		L1-M6	170.4	49.74	164.5
	L2-M1	180.5	52.19	172.5		L2-M1	178.8	53.63	169.5
	L2-M2	153.8	72.06	144		L2-M2	145.6	66.34	137.5
	L2-M3	183.7	46.77	195		L2-M3	169	42.31	157
	L2-M4	170.6	46.82	162		L2-M4	170.5	46.84	165.5
	L2-M5	187.7	49.03	202.5		L2-M5	174	47.31	168
	L2-M6	179.8	89.82	202.5		L2-M6	172.8	39.02	165
	L3-M1	174.4	52.83	159.5		L3-M1	171.1	44.16	158.5
	L3-M2	171.5	51.77	160		L3-M2	173.5	43.21	160.5
	L3-M3	176	49.91	167.5		L3-M3	176.3	42.45	167
	L3-M4	172.1	51.14	162		L3-M4	172.7	39.86	165
	L3-M5	174	48.57	156.5		L3-M5	174.8	43.87	159
	L3-M6	174	43.91	156		L3-M6	171.9	42.46	166.5
	L4-M1	173.5	55.59	168.5		L4-M1	169	50.63	162.5

L4-M2	174.7	54.07	168	L4-M2	166.2	46.86	152
L4-M3	176	55.84	170	L4-M3	170.4	51.79	165
L4-M4	177.8	58.41	172	L4-M4	172	48.18	170
L4-M5	173.4	55.66	165	L4-M5	168.9	52.14	158.5
L4-M6	177.5	56.79	174	L4-M6	167.7	45.92	164
L5-M1	170.4	50.05	158.5	L5-M1	171.2	46.23	172
L5-M2	171.8	50.64	167.5	L5-M2	172.9	50.71	176
L5-M3	172.2	53.94	163	L5-M3	170.9	49.1	168
L5-M4	172.1	51.99	166.5	L5-M4	170	47.44	167.5
L5-M5	173.6	55.73	167	L5-M5	173.8	52.75	169.5
L5-M6	171.9	57.01	163.5	L5-M6	175.1	48.92	175.5
L6-M1	179.8	55.63	177.5	L6-M1	179.7	48.4	182
L6-M2	177.3	54.21	177.5	L6-M2	181.3	48.47	181
L6-M3	177.6	55.04	171.5	L6-M3	178	49.39	178.5
L6-M4	180.7	56.71	181.5	L6-M4	179.7	49.31	178.5
L6-M5	179	54.68	178.5	L6-M5	182.4	48.03	182.5
L6-M6	177.7	51.79	177.5	L6-M6	177.3	44.95	178
L7-M1	177.5	53.41	178.5	L7-M1	180.5	49.78	179
L7-M2	207	97.33	215.5	L7-M2	207.5	81.34	225
L7-M3	176	53.92	169	L7-M3	188.1	52.99	183
L7-M4	178	56.57	172.5	L7-M4	186.2	54.56	190.5
L7-M5	180.3	53.03	180.5	L7-M5	194.4	48.71	205.5
L7-M6	180.9	55.61	180.5	L7-M6	181.5	49.36	181.5
L8-M1	177.8	55.49	180	L8-M1	180	52.68	180.5
L8-M2	214.4	106.43	214.5	L8-M2	208.4	102.59	184
L8-M3	180.7	55.52	183.5	L8-M3	181.9	49.72	177
L8-M4	178.6	57.55	178	L8-M4	182	50.78	178.5

L8-M5	174.6	56.77	174.5	L8-M5	188.5	57.57	179
L8-M6	178.7	55.58	177.5	L8-M6	186.2	56.12	183.5
L9-M1	179.5	51.28	176.5	L9-M1	181.2	54.33	178
L9-M2	178.9	51.66	178	L9-M2	177.7	52.37	171.5
L9-M3	180.9	53.15	181	L9-M3	178.1	48.83	182
L9-M4	177.2	53.19	172.5	L9-M4	177.1	49.04	175
L9-M5	182	48.96	180.5	L9-M5	178.9	48.83	179.5
L9-M6	178.8	50.57	180.5	L9-M6	177.6	48.39	181.5
L10-M1	164.4	56.35	165	L10-M1	154	57.87	153.5
L10-M2	162.2	55.55	162.5	L10-M2	155.2	58.06	151.5
L10-M3	158.6	57.57	160	L10-M3	160.4	57.65	158
L10-M4	164.6	53.88	165	L10-M4	158.2	61.62	154
L10-M5	164.2	56.61	172	L10-M5	160.3	59.98	157
L10-M6	164	55.48	171.5	L10-M6	163	59.59	158.5

b. Mean, SD & median values of F0 (Hz) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ta/	Benchmark	166.2	56.48	157.5	/da/	Benchmark	162.1	55.63	156.5
	L1-M1	170.8	55.06	172.5		L1-M1	168.5	48.09	164.5
	L1-M2	172.1	56.77	164		L1-M2	165.4	51.28	161.5
	L1-M3	172.1	54.23	166.5		L1-M3	165.8	51.17	162.5
	L1-M4	172.6	54.95	169		L1-M4	169	49.39	162.5
	L1-M5	172.3	56.23	166		L1-M5	167.8	49.52	161
	L1-M6	174.6	60.18	170.5		L1-M6	170.5	50.13	164.5
	L2-M1	181.5	53	171		L2-M1	173	33.53	166.5
	L2-M2	152.9	67.13	152		L2-M2	155.7	64.81	150
	L2-M3	179.6	51.89	172		L2-M3	172	36.74	160

L2-M4	173.6	47.47	165.5	L2-M4	174	43.22	161.5
L2-M5	174.4	51.52	175.5	L2-M5	174.4	46.71	150
L2-M6	173	47.31	173.5	L2-M6	172.9	39.76	158.5
L3-M1	171.9	44.36	167	L3-M1	168.9	43.48	159
L3-M2	172.3	47.13	165	L3-M2	168	44.12	157
L3-M3	172	41.03	165.5	L3-M3	171.2	45.31	164
L3-M4	173.9	46.03	165.5	L3-M4	168.8	41.77	160.5
L3-M5	171.8	44.64	162	L3-M5	169.2	44.03	158.5
L3-M6	172.9	43.53	162	L3-M6	168.3	44.6	154
L4-M1	174.7	55.55	172	L4-M1	168.5	49.95	163
L4-M2	177	53.21	176	L4-M2	169.6	48.72	161.5
L4-M3	177	54.81	172.5	L4-M3	169.1	53.54	163.5
L4-M4	179.8	55.34	178	L4-M4	169.6	49.03	162.5
L4-M5	175.4	54.23	174	L4-M5	168.6	49.09	160.5
L4-M6	178	54.1	175	L4-M6	170.7	48.59	163.5
L5-M1	172.8	49.96	162	L5-M1	167.6	45	169.5
L5-M2	172.8	50.09	167	L5-M2	170	48.07	167
L5-M3	175.1	53.39	168	L5-M3	167.7	48.39	166
L5-M4	173.9	52.56	164.5	L5-M4	168.8	44.17	168
L5-M5	175.5	54.01	167	L5-M5	171.1	48.19	163.5
L5-M6	176.7	58.1	173.5	L5-M6	172.3	47.67	170
L6-M1	178.5	53.18	172	L6-M1	172.3	47.85	170.5
L6-M2	176.1	52.02	176	L6-M2	177.2	50.04	180.5
L6-M3	178.6	50.99	178	L6-M3	174	48.83	178.5
L6-M4	176.5	52.62	173.5	L6-M4	176.3	49.82	177.5
L6-M5	179.2	53.33	181	L6-M5	176.9	47.51	180
L6-M6	175.9	51.17	178	L6-M6	175.8	49.17	177

L7-M1	171.2	44.96	166	L7-M1	180.8	48.13	178.5
L7-M2	200.5	88.17	201.5	L7-M2	206.4	80.12	222
L7-M3	171.3	41.58	164.5	L7-M3	183.1	49.59	184.5
L7-M4	174.4	45.61	165.5	L7-M4	183.2	49.19	181.5
L7-M5	173.4	43.16	162	L7-M5	183.4	52.32	187
L7-M6	173	43.44	162	L7-M6	182.2	51.93	180.5
L8-M1	180.4	54.31	174.5	L8-M1	183.5	50.32	185.5
L8-M2	214.8	100.34	216.5	L8-M2	211.5	104.15	189.5
L8-M3	179.2	57.92	176	L8-M3	185	50.21	179.5
L8-M4	180.1	55.58	172.5	L8-M4	186.7	48.8	182
L8-M5	180.8	56.93	174	L8-M5	184.6	52.39	183
L8-M6	181.8	56.59	178.5	L8-M6	186.1	52.85	186
L9-M1	178.1	54.09	172	L9-M1	186.5	55.05	186.5
L9-M2	174.9	55.55	171	L9-M2	181.5	52.5	181.5
L9-M3	179	52.22	180	L9-M3	182	52.99	185.5
L9-M4	176.9	52.8	180.5	L9-M4	187.6	53.37	189.5
L9-M5	176.5	54.72	179	L9-M5	188.3	57.95	192
L9-M6	178.4	54.37	175	L9-M6	189.1	57.76	188.5
L10-M1	159.7	56.68	157	L10-M1	160.9	53.33	158.5
L10-M2	159.7	56.87	150	L10-M2	160.1	51.64	163.5
L10-M3	159.5	55.83	150.5	L10-M3	155.2	50.71	157
L10-M4	163.1	56.45	152.5	L10-M4	162.5	56.95	170
L10-M5	164.9	57.03	160	L10-M5	163.7	55.99	166.5
L10-M6	164.2	60.12	160	L10-M6	164.4	55.64	163

c. Mean, SD & median values of F0 (Hz) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median

/ka/	Benchmark	167.9	56.77	164.5	/ga/	Benchmark	165.3	54.76	156.5
	L1-M1	173.3	53.17	170		L1-M1	167.9	44.37	167
	L1-M2	172.3	56.14	167.5		L1-M2	167	50.38	159
	L1-M3	174.6	58.58	164.5		L1-M3	169.7	50.81	168
	L1-M4	175.9	53.63	170.5		L1-M4	166.7	50.26	158
	L1-M5	174.7	54.85	167.5		L1-M5	167.5	49.56	165
	L1-M6	178.3	56.84	176		L1-M6	172.3	52.71	156.5
	L2-M1	228.5	103.23	204		L2-M1	187.6	47.52	176
	L2-M2	165.1	67.04	175		L2-M2	160	65.07	170
	L2-M3	184	39.79	194		L2-M3	182.2	33.36	180
	L2-M4	191.5	39.65	200		L2-M4	184.6	41.44	181
	L2-M5	184.7	44.49	193		L2-M5	184.3	41.35	176
	L2-M6	193	35.27	202.5		L2-M6	179.2	35.13	170.5
	L3-M1	172.3	47.23	166.5		L3-M1	168.7	42.59	156
	L3-M2	171.3	45.84	162		L3-M2	169	43.7	155.5
	L3-M3	173.8	46.28	166.5		L3-M3	173.6	45.39	165.5
	L3-M4	174.4	49.14	161		L3-M4	172.3	43.08	162.5
	L3-M5	181.1	47.21	194.5		L3-M5	173.9	45.66	155
	L3-M6	171.8	48.02	159.5		L3-M6	171.9	44.99	157.5
	L4-M1	178.3	55.39	179.5		L4-M1	168.5	48.94	163
	L4-M2	179.4	53.96	176.5		L4-M2	170.7	49.84	166.5
	L4-M3	179.3	56.68	173		L4-M3	172.1	54.27	167.5
	L4-M4	182	55.63	174.5		L4-M4	169.1	48.04	166
	L4-M5	177.3	56.65	172.5		L4-M5	169.3	49.21	162
	L4-M6	178.8	54.92	172.5		L4-M6	173.2	49.88	169
	L5-M1	179.8	48.54	178		L5-M1	170.6	43.4	168.5
	L5-M2	182.2	50.61	183		L5-M2	170.9	44.93	173.5

L5-M3	180.9	50.71	181	L5-M3	172.2	45.93	171
L5-M4	177.8	47.91	176	L5-M4	171.9	48.15	170
L5-M5	180.3	50.56	177.5	L5-M5	177.4	47.96	181.5
L5-M6	181.1	50.76	178	L5-M6	179.2	49.09	180
L6-M1	178.5	55.91	173.5	L6-M1	175.3	45.87	171.5
L6-M2	177.4	55.62	178.5	L6-M2	174.9	46.69	176
L6-M3	178.7	55.58	178.5	L6-M3	174.4	44.55	173.5
L6-M4	179.6	55.44	175	L6-M4	174.8	48.1	173
L6-M5	180.4	53.02	182.5	L6-M5	174.6	47.29	175.5
L6-M6	175.7	54.81	176.5	L6-M6	174.2	50.66	178.5
L7-M1	187.1	51.65	183.5	L7-M1	179.9	52.98	177.5
L7-M2	222.1	105.01	233.5	L7-M2	212.9	98.21	223.5
L7-M3	188.5	56.47	187.5	L7-M3	181.9	51.49	178.5
L7-M4	195.6	57.66	200.5	L7-M4	184.3	51.07	180
L7-M5	191.3	56.1	188	L7-M5	181	48.59	179.5
L7-M6	192.8	57.88	188	L7-M6	186.1	54.05	186.5
L8-M1	189.1	43.12	198	L8-M1	182.6	44.49	188
L8-M2	225.1	105.16	219	L8-M2	207.9	90.43	183
L8-M3	188.8	47.33	186.5	L8-M3	193.2	49.61	193.5
L8-M4	192.6	43.29	190	L8-M4	185.6	44.97	187.5
L8-M5	195.2	43.86	195.5	L8-M5	195.2	54.02	201.5
L8-M6	188.1	48.41	185	L8-M6	188.2	47.47	197.5
L9-M1	183.9	45.68	190	L9-M1	179.6	47.71	196.5
L9-M2	181.2	47.19	186	L9-M2	184.5	49.25	193
L9-M3	183.3	45.23	190.5	L9-M3	183.5	44.58	196
L9-M4	180.4	46.87	184.5	L9-M4	184.3	47.31	192.5
L9-M5	181.6	45.02	187	L9-M5	180.8	46.32	189

L9-M6	180.1	43.93	185.5	L9-M6	176.3	43.71	187
L10-M1	161.9	55.81	160	L10-M1	156.6	60.06	160
L10-M2	159.8	54.62	155	L10-M2	161.2	61.63	166.5
L10-M3	163.6	55.4	160	L10-M3	164.2	61.19	162
L10-M4	162.7	60.85	158.5	L10-M4	164.5	55.54	166.5
L10-M5	163.2	56.24	158	L10-M5	167.6	54.22	164
L10-M6	165.8	58	164.5	L10-M6	167	56.64	162.5

d. Mean, SD & median values of F0 (Hz) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	170.6	58.17	165	/dha/	Benchmark	164.6	55.98	154.5
	L1-M1	171.6	54.22	170.5		L1-M1	166.4	44.95	165.5
	L1-M2	169.5	54	167.5		L1-M2	162	44.93	157.5
	L1-M3	173.5	54.83	166.5		L1-M3	168.2	47.47	165
	L1-M4	174.8	53.42	169.5		L1-M4	164.7	48.17	162.5
	L1-M5	172.9	55	167		L1-M5	165.8	49.93	165
	L1-M6	176.2	57.1	165		L1-M6	164.7	49.11	156.5
	L2-M1	183.5	36.15	189.5		L2-M1	185.5	42.51	172
	L2-M2	161.3	67.64	181.5		L2-M2	156.2	65.07	156.5
	L2-M3	180.6	40.51	185		L2-M3	167.2	45.38	150
	L2-M4	152.8	88.49	176.5		L2-M4	181.4	46.94	177
	L2-M5	184.5	45.12	189		L2-M5	177.9	41.63	163.5
	L2-M6	182.3	40.49	185.5		L2-M6	177.3	36.67	168.5
	L3-M1	173.3	42.38	161.		L3-M1	170.5	42.52	157.5
	L3-M2	172.8	42.46	158.		L3-M2	171.1	43.03	160.5
	L3-M3	178.9	45.08	166.5		L3-M3	172.2	44.2	166
	L3-M4	178	45.87	162		L3-M4	171.2	41.29	161

L3-M5	179.9	46.67	158.5	L3-M5	175	45.16	161
L3-M6	177.8	41.44	163	L3-M6	171.6	45.77	158.5
L4-M1	175.3	52.53	173	L4-M1	169.9	47.03	161
L4-M2	177	50.8	176	L4-M2	168.1	48.99	158.5
L4-M3	177.4	55.25	171.5	L4-M3	170.4	50.48	169.5
L4-M4	177.3	55.08	175	L4-M4	170.9	47.64	167.5
L4-M5	175.8	57.97	171.5	L4-M5	167.9	47.33	158
L4-M6	177.3	57.17	172	L4-M6	171.5	47.73	167
L5-M1	178.4	49.79	169	L5-M1	176.1	47.34	174
L5-M2	176	51.33	171.5	L5-M2	177.8	47.89	177
L5-M3	176.7	50.1	172.5	L5-M3	172.3	45.94	157.5
L5-M4	174.4	51.47	170	L5-M4	173.2	51.76	158
L5-M5	173.8	51.35	173.5	L5-M5	173.5	44.89	167
L5-M6	173.1	50.94	177.5	L5-M6	174.2	46.04	169
L6-M1	184.3	57.87	180.5	L6-M1	171.1	48.17	176
L6-M2	181.9	48.32	185.5	L6-M2	172.9	47.29	174.5
L6-M3	177.7	51.83	179	L6-M3	174.5	47.98	180
L6-M4	182.5	57.39	180.5	L6-M4	174.2	51.64	174.5
L6-M5	181.7	52.78	180.5	L6-M5	173.5	46.51	178
L6-M6	178.5	52.59	180.5	L6-M6	171.3	46.59	173.5
L7-M1	184.4	56.49	182	L7-M1	185.7	55.06	182
L7-M2	216.5	98.48	228	L7-M2	217.4	79.86	231
L7-M3	181.5	52.82	179	L7-M3	189.7	55.15	187
L7-M4	186.8	51.3	188	L7-M4	197.6	60.56	194
L7-M5	184.6	51.49	185	L7-M5	196.5	53.72	194.5
L7-M6	186.2	54.39	188.5	L7-M6	194.9	56.69	193
L8-M1	185.1	52.58	179	L8-M1	183.4	49.41	176

L8-M2	215.9	99.62	206	L8-M2	217	105.52	188.5
L8-M3	181.8	56.23	184.5	L8-M3	185.9	50.63	177
L8-M4	186	53.02	177.5	L8-M4	187.4	50.64	180
L8-M5	185.5	53.13	181	L8-M5	188.2	53.98	180
L8-M6	183.9	53.82	179.5	L8-M6	186.7	54.06	180
L9-M1	179	54.94	177	L9-M1	187.1	56.59	187.5
L9-M2	176.4	55.16	171	L9-M2	182.4	54.83	180
L9-M3	176.7	53.2	176.5	L9-M3	185.1	53.16	184
L9-M4	177.3	52.49	181.5	L9-M4	186.8	54	191
L9-M5	176.4	53.41	177.5	L9-M5	188.3	58.86	196
L9-M6	177.5	55.01	179.5	L9-M6	189.1	58.79	193.5
L10-M1	165.7	60.54	165.5	L10-M1	158.1	57.92	155
L10-M2	166.4	59.43	170	L10-M2	158.1	58.67	155.5
L10-M3	166.8	69.61	164.5	L10-M3	165.6	56.93	188
L10-M4	160.5	67.46	155	L10-M4	162.9	59.15	151.5
L10-M5	163.4	65.75	162	L10-M5	161.1	65.35	150.5
L10-M6	168.4	61.76	165	L10-M6	163.2	57.87	164.5

Table 6

a. Mean, SD & median values of F1 (Hz) for sounds /pa/ and /ba/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/pa/	Benchmark	757.10	84.45	727.00	/ba/	Benchmark	651.40	87.51	607.50
	L1-M1	722.30	142.60	720.00		L1-M1	658.60	116.84	640.00
	L1-M2	667.70	136.34	710.50		L1-M2	626.20	132.27	622.50
	L1-M3	729.40	162.05	718.50		L1-M3	634.80	108.23	634.50
	L1-M4	687.30	140.96	676.50		L1-M4	613.40	114.74	594.00
	L1-M5	705.90	142.34	691.50		L1-M5	643.90	111.63	633.00
	L1-M6	735.50	143.60	714.50		L1-M6	669.30	125.51	635.50

L2-M1	786.60	119.42	775.50	L2-M1	580.60	132.90	679.00
L2-M2	758.30	117.78	743.00	L2-M2	617.90	150.21	725.00
L2-M3	758.30	130.93	766.50	L2-M3	596.90	132.55	717.00
L2-M4	750.00	129.60	759.00	L2-M4	604.40	142.81	717.00
L2-M5	766.80	137.80	770.00	L2-M5	604.80	129.22	747.00
L2-M6	744.60	134.35	742.50	L2-M6	607.60	138.85	718.00
L3-M1	763.90	144.97	782.00	L3-M1	672.70	164.62	723.00
L3-M2	755.40	140.94	784.00	L3-M2	756.20	126.43	796.00
L3-M3	762.50	150.05	807.50	L3-M3	764.40	133.80	801.50
L3-M4	734.20	127.00	761.00	L3-M4	753.90	124.70	786.00
L3-M5	739.10	134.87	767.00	L3-M5	767.80	125.74	795.50
L3-M6	752.00	136.89	798.00	L3-M6	740.00	117.00	705.00
L4-M1	792.10	80.23	821.00	L4-M1	748.40	117.08	725.50
L4-M2	782.00	83.60	774.00	L4-M2	720.30	93.61	734.50
L4-M3	809.20	81.21	831.00	L4-M3	747.70	107.60	751.00
L4-M4	763.90	80.78	746.00	L4-M4	724.20	120.62	747.50
L4-M5	802.40	97.41	814.50	L4-M5	742.20	88.98	746.50
L4-M6	798.20	76.44	821.50	L4-M6	731.40	88.30	743.50
L5-M1	741.00	73.52	725.00	L5-M1	676.40	98.01	696.00
L5-M2	747.70	81.65	727.00	L5-M2	654.10	96.41	619.50
L5-M3	777.70	94.65	745.50	L5-M3	684.70	101.17	668.00
L5-M4	767.80	95.71	759.50	L5-M4	668.50	82.80	635.00
L5-M5	752.40	100.52	715.00	L5-M5	652.20	86.78	655.50
L5-M6	744.60	89.53	707.50	L5-M6	637.40	74.87	629.00
L6-M1	754.10	100.11	723.50	L6-M1	676.60	71.54	672.50
L6-M2	745.20	81.09	750.00	L6-M2	666.70	86.77	648.00
L6-M3	750.10	91.29	739.00	L6-M3	660.60	90.39	646.50
L6-M4	723.50	68.09	700.50	L6-M4	664.60	91.47	643.00
L6-M5	826.00	135.04	817.00	L6-M5	725.90	169.78	657.00
L6-M6	723.10	77.57	708.50	L6-M6	668.80	86.78	648.00

L7-M1	721.50	46.35	722.00	L7-M1	681.40	71.63	692.00
L7-M2	767.70	94.57	765.00	L7-M2	720.60	114.68	722.00
L7-M3	722.30	44.56	727.50	L7-M3	702.90	83.03	705.00
L7-M4	727.90	51.14	728.50	L7-M4	692.50	65.72	695.00
L7-M5	739.70	65.70	733.00	L7-M5	709.40	109.01	698.00
L7-M6	759.20	51.40	767.50	L7-M6	717.50	108.96	710.50
L8-M1	726.60	58.01	727.00	L8-M1	688.90	78.15	694.00
L8-M2	789.70	115.48	748.50	L8-M2	744.70	166.16	688.50
L8-M3	748.40	59.08	740.00	L8-M3	698.10	42.22	696.00
L8-M4	734.50	58.81	729.00	L8-M4	698.10	75.20	708.50
L8-M5	746.50	59.45	759.50	L8-M5	682.90	74.75	690.50
L8-M6	730.90	62.46	732.00	L8-M6	696.00	70.31	690.00
L9-M1	733.50	76.95	705.00	L9-M1	698.50	108.73	670.00
L9-M2	731.40	75.46	738.50	L9-M2	708.20	88.76	725.50
L9-M3	735.20	95.63	762.00	L9-M3	723.90	97.12	717.50
L9-M4	748.20	77.10	762.00	L9-M4	715.50	88.57	717.00
L9-M5	727.30	75.63	730.00	L9-M5	709.60	100.90	702.00
L9-M6	735.20	76.75	730.50	L9-M6	689.10	133.63	726.00
L10-M1	731.10	81.28	723.00	L10-M1	645.10	90.78	622.00
L10-M2	742.00	78.92	783.50	L10-M2	647.80	91.05	629.00
L10-M3	735.90	81.16	740.00	L10-M3	644.20	99.92	661.00
L10-M4	732.20	80.50	734.50	L10-M4	668.50	92.11	665.50
L10-M5	733.90	83.71	732.00	L10-M5	679.00	88.60	683.00
L10-M6	735.80	85.42	727.00	L10-M6	677.10	88.22	672.00

b. Mean, SD & median values of F1 (Hz) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ta/	Benchmark	751.30	82.93	762.50	/da/	Benchmark	691.60	92.90	673.50
	L1-M1	743.90	78.87	768.00		L1-M1	667.20	97.39	648.50

L1-M2	747.40	78.76	758.50	L1-M2	655.80	112.46	655.00
L1-M3	733.30	76.50	705.50	L1-M3	650.90	94.69	639.50
L1-M4	722.10	110.25	735.00	L1-M4	657.10	59.71	652.00
L1-M5	728.30	88.04	704.00	L1-M5	656.40	95.63	650.00
L1-M6	755.80	96.83	750.50	L1-M6	684.20	100.49	664.00
L2-M1	785.10	92.22	796.00	L2-M1	621.40	138.16	742.00
L2-M2	761.30	198.95	707.00	L2-M2	606.80	134.33	724.50
L2-M3	750.30	124.26	760.00	L2-M3	595.60	139.08	710.50
L2-M4	758.40	130.11	750.00	L2-M4	600.20	134.46	722.50
L2-M5	760.10	142.10	778.00	L2-M5	609.70	136.70	721.50
L2-M6	769.70	129.95	759.00	L2-M6	605.00	131.79	720.00
L3-M1	775.30	110.28	780.00	L3-M1	776.10	120.18	820.00
L3-M2	788.40	111.35	791.50	L3-M2	678.00	161.84	772.50
L3-M3	781.10	118.28	825.00	L3-M3	760.40	127.99	787.00
L3-M4	704.30	136.10	800.00	L3-M4	759.30	107.41	775.50
L3-M5	797.30	102.04	795.50	L3-M5	777.60	116.63	791.00
L3-M6	773.50	98.74	768.50	L3-M6	755.20	111.89	757.50
L4-M1	805.90	98.39	811.50	L4-M1	726.60	87.83	710.00
L4-M2	795.20	90.10	772.00	L4-M2	692.80	71.47	688.00
L4-M3	798.10	71.83	815.50	L4-M3	747.80	83.56	746.50
L4-M4	786.20	87.81	777.50	L4-M4	721.00	97.00	706.00
L4-M5	785.40	82.77	773.00	L4-M5	713.70	67.06	715.00
L4-M6	797.20	89.90	775.00	L4-M6	726.40	76.67	713.50
L5-M1	753.40	80.78	771.00	L5-M1	732.60	109.80	736.00
L5-M2	751.90	95.52	732.50	L5-M2	724.00	119.95	740.50
L5-M3	766.20	79.83	793.00	L5-M3	748.60	97.15	786.00
L5-M4	750.70	86.54	744.50	L5-M4	716.90	106.41	701.00
L5-M5	727.80	86.28	704.00	L5-M5	714.00	111.88	705.50
L5-M6	742.80	88.08	732.50	L5-M6	728.40	119.50	687.00
L6-M1	763.70	89.94	769.50	L6-M1	716.10	83.00	698.50

L6-M2	747.00	89.15	752.50	L6-M2	699.70	88.84	705.50
L6-M3	748.00	88.26	732.00	L6-M3	713.40	80.06	722.00
L6-M4	743.60	81.73	710.00	L6-M4	711.10	92.70	706.50
L6-M5	807.60	123.82	824.00	L6-M5	768.50	100.29	760.50
L6-M6	741.60	84.00	747.00	L6-M6	708.10	87.60	693.50
L7-M1	728.30	88.19	732.00	L7-M1	698.80	38.31	693.00
L7-M2	720.00	98.70	735.00	L7-M2	729.60	62.40	727.00
L7-M3	722.40	85.28	693.50	L7-M3	675.90	45.76	670.00
L7-M4	718.80	92.96	717.50	L7-M4	689.70	57.13	685.00
L7-M5	717.10	79.67	705.50	L7-M5	701.90	58.69	714.00
L7-M6	715.90	84.69	726.50	L7-M6	725.90	55.71	736.00
L8-M1	742.20	86.57	722.00	L8-M1	717.10	86.64	720.50
L8-M2	812.20	213.92	741.50	L8-M2	763.20	110.15	723.50
L8-M3	745.10	100.57	735.00	L8-M3	758.60	93.03	740.00
L8-M4	768.20	108.57	767.00	L8-M4	696.20	62.33	719.00
L8-M5	794.40	111.35	772.00	L8-M5	749.10	58.29	732.50
L8-M6	757.70	108.19	719.50	L8-M6	737.60	58.53	722.50
L9-M1	718.10	88.61	705.00	L9-M1	703.40	76.19	706.00
L9-M2	734.40	100.95	716.50	L9-M2	725.00	81.93	730.50
L9-M3	741.60	70.00	738.50	L9-M3	729.80	79.04	753.50
L9-M4	747.00	82.23	757.00	L9-M4	702.90	88.22	717.50
L9-M5	759.70	80.10	737.50	L9-M5	693.60	61.76	713.00
L9-M6	749.40	77.03	723.00	L9-M6	712.70	85.59	719.50
L10-M1	709.60	91.52	722.50	L10-M1	687.00	99.76	674.50
L10-M2	726.40	94.75	745.00	L10-M2	684.90	96.66	690.00
L10-M3	727.70	91.45	742.00	L10-M3	681.60	98.83	659.00
L10-M4	720.20	86.88	733.50	L10-M4	680.50	100.68	663.00
L10-M5	729.00	92.20	750.50	L10-M5	680.10	97.34	667.50
L10-M6	737.90	89.49	788.50	L10-M6	691.20	86.85	683.00

c. Mean, SD & median values of F1 (Hz) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ka/	Benchmark	775.90	86.92	781.50	/ga/	Benchmark	677.50	97.10	653.50
	L1-M1	751.10	139.84	734.50		L1-M1	673.20	101.73	681.50
	L1-M2	719.70	109.30	711.00		L1-M2	623.70	90.68	625.50
	L1-M3	736.60	109.54	747.00		L1-M3	661.20	100.58	675.00
	L1-M4	698.60	102.41	704.50		L1-M4	640.10	100.48	653.00
	L1-M5	716.80	117.09	674.50		L1-M5	656.60	102.57	648.00
	L1-M6	750.20	130.64	754.50		L1-M6	688.20	123.69	663.00
	L2-M1	770.20	124.67	782.00		L2-M1	511.10	164.47	636.50
	L2-M2	810.60	103.14	739.00		L2-M2	595.80	138.58	717.50
	L2-M3	726.50	122.34	743.00		L2-M3	565.30	120.23	675.00
	L2-M4	726.20	129.00	680.00		L2-M4	573.90	128.26	663.50
	L2-M5	738.80	142.63	710.00		L2-M5	563.70	112.40	670.00
	L2-M6	757.90	123.38	771.00		L2-M6	586.30	126.62	675.00
	L3-M1	793.80	120.98	828.00		L3-M1	714.80	159.90	803.00
	L3-M2	796.50	123.00	848.50		L3-M2	808.70	66.67	824.00
	L3-M3	804.60	118.40	846.50		L3-M3	805.70	67.00	813.50
	L3-M4	785.40	114.45	818.00		L3-M4	795.40	64.78	796.00
	L3-M5	806.90	120.25	822.00		L3-M5	817.00	87.94	825.00
	L3-M6	770.10	123.18	792.50		L3-M6	762.90	60.87	742.50
	L4-M1	809.20	107.27	813.00		L4-M1	732.60	79.64	710.00
	L4-M2	791.60	89.18	782.50		L4-M2	704.20	68.07	692.00
	L4-M3	812.50	86.20	842.50		L4-M3	753.00	113.25	747.00
	L4-M4	783.40	84.39	794.00		L4-M4	709.50	72.93	702.00
	L4-M5	790.90	88.45	822.50		L4-M5	717.80	74.04	700.00
	L4-M6	791.50	78.96	800.00		L4-M6	720.60	64.58	719.00

L5-M1	773.00	79.16	771.00	L5-M1	750.20	57.54	757.00
L5-M2	767.20	86.38	761.50	L5-M2	734.30	111.09	733.00
L5-M3	755.10	62.66	761.50	L5-M3	729.50	97.44	728.50
L5-M4	765.20	91.51	798.50	L5-M4	718.10	76.44	716.50
L5-M5	777.70	94.93	796.50	L5-M5	713.90	82.55	710.50
L5-M6	757.60	72.25	749.50	L5-M6	705.00	102.52	718.00
L6-M1	767.40	78.79	784.00	L6-M1	684.90	86.54	675.50
L6-M2	773.00	69.49	790.00	L6-M2	675.60	88.52	662.50
L6-M3	765.50	87.19	801.50	L6-M3	671.40	72.56	680.00
L6-M4	773.90	75.24	790.50	L6-M4	617.80	205.06	684.00
L6-M5	840.90	113.98	814.00	L6-M5	744.40	123.19	729.50
L6-M6	755.00	93.21	775.50	L6-M6	676.10	77.65	655.50
L7-M1	765.20	84.13	746.00	L7-M1	676.80	70.23	686.00
L7-M2	803.20	87.18	807.50	L7-M2	693.50	88.62	681.50
L7-M3	789.10	88.69	765.00	L7-M3	655.90	58.08	654.00
L7-M4	776.20	66.94	778.50	L7-M4	656.70	59.41	651.50
L7-M5	778.50	64.42	776.00	L7-M5	667.20	59.40	647.50
L7-M6	779.30	50.10	766.00	L7-M6	676.40	54.97	674.50
L8-M1	729.10	70.78	726.00	L8-M1	676.20	83.13	666.00
L8-M2	743.40	141.03	737.00	L8-M2	767.20	153.37	717.00
L8-M3	729.90	71.56	743.50	L8-M3	682.50	43.28	683.50
L8-M4	714.20	71.36	719.00	L8-M4	674.40	75.77	677.00
L8-M5	722.30	47.64	723.00	L8-M5	668.40	66.62	667.00
L8-M6	728.50	52.72	722.50	L8-M6	668.90	50.86	665.00
L9-M1	699.30	73.27	689.00	L9-M1	668.60	90.15	644.50
L9-M2	718.50	98.20	683.00	L9-M2	699.10	107.96	724.50
L9-M3	728.60	71.75	707.50	L9-M3	674.60	85.69	719.00
L9-M4	721.30	82.41	696.00	L9-M4	710.70	93.41	719.00
L9-M5	715.40	70.53	700.50	L9-M5	673.90	92.22	718.00
L9-M6	717.80	92.03	695.00	L9-M6	684.80	95.80	723.00

L10-M1	733.50	76.95	705.00	L10-M1	698.50	108.73	670.00
L10-M2	731.40	75.46	738.50	L10-M2	708.20	88.76	725.50
L10-M3	735.20	95.63	762.00	L10-M3	723.90	97.12	717.50
L10-M4	748.20	77.10	762.00	L10-M4	715.50	88.57	717.00
L10-M5	727.30	75.63	730.00	L10-M5	709.60	100.90	702.00
L10-M6	735.20	76.75	730.50	L10-M6	689.10	133.63	726.00

d. Mean, SD & median values of F1 (Hz) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	750.10	100.83	742.00	/dha/	Benchmark	675.90	67.94	665.50
	L1-M1	730.40	140.13	779.00		L1-M1	657.20	130.97	635.50
	L1-M2	724.00	88.54	734.00		L1-M2	632.30	129.02	633.00
	L1-M3	736.20	89.40	775.00		L1-M3	654.30	132.07	636.50
	L1-M4	678.80	130.76	690.50		L1-M4	604.10	119.15	614.50
	L1-M5	716.90	107.03	691.00		L1-M5	647.90	127.67	633.50
	L1-M6	706.10	141.39	727.50		L1-M6	674.00	131.79	642.00
	L2-M1	766.20	127.98	774.50		L2-M1	609.60	139.07	751.00
	L2-M2	785.50	249.79	743.00		L2-M2	654.90	120.89	736.00
	L2-M3	726.70	120.90	760.00		L2-M3	576.10	128.96	670.00
	L2-M4	739.90	150.57	723.00		L2-M4	560.70	112.51	661.00
	L2-M5	722.30	114.18	754.00		L2-M5	579.00	117.93	682.00
	L2-M6	760.80	110.55	772.00		L2-M6	598.40	129.60	698.00
	L3-M1	781.70	140.37	805.50		L3-M1	795.20	90.19	790.00
	L3-M2	783.90	120.40	827.00		L3-M2	802.40	73.04	807.50
	L3-M3	768.80	134.70	828.50		L3-M3	796.30	85.31	800.50
	L3-M4	774.30	112.04	810.50		L3-M4	814.50	60.69	817.00
	L3-M5	810.60	122.71	850.00		L3-M5	801.70	75.47	803.50
	L3-M6	767.70	109.41	794.00		L3-M6	795.60	63.22	793.50
	L4-M1	780.80	122.86	796.50		L4-M1	746.00	87.70	731.50
	L4-M2	754.60	94.69	760.00		L4-M2	722.50	93.46	710.50

L4-M3	765.80	101.79	793.50	L4-M3	753.60	91.48	751.00
L4-M4	766.00	100.00	788.50	L4-M4	744.40	88.48	734.00
L4-M5	764.90	108.29	767.50	L4-M5	740.60	83.75	747.50
L4-M6	774.20	97.23	764.50	L4-M6	761.90	88.43	750.50
L5-M1	760.80	86.85	773.00	L5-M1	704.20	68.99	723.00
L5-M2	737.90	118.75	705.50	L5-M2	721.80	151.07	695.00
L5-M3	755.20	103.86	724.50	L5-M3	728.90	79.53	726.00
L5-M4	752.00	99.7	749.00	L5-M4	711.30	95.58	714.50
L5-M5	722.50	117.94	682.00	L5-M5	696.50	108.94	720.00
L5-M6	747.00	95.98	743.00	L5-M6	703.20	108.33	708.00
L6-M1	744.30	83.44	729.00	L6-M1	681.50	54.77	683.00
L6-M2	750.40	92.04	744.00	L6-M2	679.20	73.79	678.50
L6-M3	737.40	103.19	704.50	L6-M3	661.70	65.37	662.00
L6-M4	723.70	109.19	712.00	L6-M4	670.10	60.81	655.00
L6-M5	805.90	103.59	827.00	L6-M5	723.70	96.70	700.00
L6-M6	749.90	87.49	744.50	L6-M6	654.70	66.20	639.00
L7-M1	765.90	84.06	756.00	L7-M1	720.70	74.27	710.50
L7-M2	773.40	98.29	785.00	L7-M2	731.00	77.87	739.00
L7-M3	757.90	94.55	789.00	L7-M3	717.10	77.27	705.50
L7-M4	778.80	111.78	746.00	L7-M4	715.70	97.77	719.00
L7-M5	753.80	74.84	772.50	L7-M5	744.10	86.67	744.50
L7-M6	767.70	85.82	788.00	L7-M6	764.10	84.03	746.50
L8-M1	753.40	63.10	738.50	L8-M1	722.00	75.87	718.50
L8-M2	756.20	126.35	733.50	L8-M2	803.10	146.66	765.00
L8-M3	745.90	62.83	740.00	L8-M3	764.40	76.77	777.50
L8-M4	755.90	56.13	760.50	L8-M4	701.30	98.45	706.00
L8-M5	766.00	40.30	765.00	L8-M5	733.20	40.91	720.50
L8-M6	750.50	49.15	750.50	L8-M6	712.40	82.96	708.00
L9-M1	732.30	80.47	711.00	L9-M1	694.20	59.72	697.50
L9-M2	750.10	73.94	752.50	L9-M2	749.00	75.10	735.00

L9-M3	763.10	96.38	734.00	L9-M3	718.40	61.86	722.00
L9-M4	753.90	92.37	743.00	L9-M4	701.70	66.93	702.50
L9-M5	769.90	86.25	775.00	L9-M5	710.60	57.10	702.00
L9-M6	767.10	107.37	773.50	L9-M6	722.20	56.78	723.00
L10-M1	736.90	104.11	737.50	L10-M1	669.40	66.85	660.50
L10-M2	737.80	108.99	739.00	L10-M2	668.50	64.53	663.00
L10-M3	737.60	110.90	733.50	L10-M3	673.20	66.43	664.50
L10-M4	739.90	112.24	731.50	L10-M4	674.00	62.97	666.00
L10-M5	740.40	107.46	729.50	L10-M5	669.50	60.20	669.00
L10-M6	747.70	109.75	739.50	L10-M6	670.00	61.56	668.00

Table 7

a. Mean, SD & median values of F2 (Hz) for sounds /pa/ and /ba/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/pa/	Benchmark	1417.40	118.76	1382.00	/ba/	Benchmark	1392.00	125.82	1405.50
	L1-M1	1415.70	98.43	1382.50		L1-M1	1397.90	110.00	1392.50
	L1-M2	1373.70	130.42	1356.50		L1-M2	1330.00	172.46	1330.50
	L1-M3	1392.40	178.81	1357.50		L1-M3	1420.90	129.16	1428.00
	L1-M4	1408.40	130.02	1380.50		L1-M4	1396.70	108.77	1380.50
	L1-M5	1406.10	118.99	1358.00		L1-M5	1381.40	79.98	1370.00
	L1-M6	1429.50	129.77	1372.00		L1-M6	1397.40	114.72	1406.50
	L2-M1	1385.40	91.16	1373.50		L2-M1	1097.60	189.97	1355.50
	L2-M2	1433.20	227.21	1394.50		L2-M2	1220.50	102.96	1409.00
	L2-M3	1362.20	105.10	1375.50		L2-M3	1164.70	121.87	1404.00
	L2-M4	1375.00	139.30	1362.50		L2-M4	1133.20	108.59	1390.00
	L2-M5	1381.20	82.36	1385.00		L2-M5	1161.60	123.46	1343.00
	L2-M6	1442.90	179.95	1397.00		L2-M6	1165.90	124.31	1389.50
	L3-M1	1367.90	104.71	1370.50		L3-M1	1245.40	144.02	1394.00
	L3-M2	1343.90	111.00	1302.00		L3-M2	1364.70	100.68	1392.50

L3-M3	1335.90	65.86	1319.00	L3-M3	1393.20	137.34	1376.00
L3-M4	1338.40	76.41	1313.00	L3-M4	2549.10	157.78	1431.50
L3-M5	1353.30	90.41	1331.00	L3-M5	1399.20	142.26	1387.50
L3-M6	1375.20	100.68	1370.50	L3-M6	1391.10	140.27	1384.00
L4-M1	1367.10	129.69	1345.00	L4-M1	1414.20	170.50	1363.00
L4-M2	1380.10	138.57	1419.00	L4-M2	1420.40	181.49	1443.00
L4-M3	1365.30	154.70	1370.00	L4-M3	1402.10	162.78	1399.50
L4-M4	1332.20	133.12	1312.50	L4-M4	1430.70	227.13	1325.00
L4-M5	1398.40	162.59	1410.00	L4-M5	1394.60	176.55	1317.50
L4-M6	1373.90	157.62	1422.50	L4-M6	1375.10	212.35	1317.00
L5-M1	1375.40	72.77	1354.00	L5-M1	1404.10	124.63	1411.50
L5-M2	1368.00	98.03	1358.00	L5-M2	1397.70	122.74	1398.50
L5-M3	1391.00	128.71	1367.50	L5-M3	1402.90	118.57	1417.00
L5-M4	1397.80	147.48	1383.00	L5-M4	1415.10	117.14	1401.50
L5-M5	1373.80	148.65	1314.00	L5-M5	1397.00	115.82	1395.50
L5-M6	1371.00	163.65	1331.00	L5-M6	1400.20	119.10	1376.50
L6-M1	1427.20	81.00	1411.50	L6-M1	2418.80	186.75	1327.00
L6-M2	1395.80	83.42	1371.50	L6-M2	1293.30	61.69	1288.00
L6-M3	1383.90	98.13	1375.00	L6-M3	1305.40	111.78	1313.50
L6-M4	1383.10	138.79	1384.00	L6-M4	1347.30	66.32	1332.00
L6-M5	1374.80	117.17	1386.00	L6-M5	1339.60	57.94	1351.50
L6-M6	1377.70	127.03	1382.50	L6-M6	1336.10	87.61	1335.00
L7-M1	1289.60	70.83	1287.00	L7-M1	1296.80	111.13	1236.00
L7-M2	1397.10	197.80	1330.50	L7-M2	1431.20	189.09	1302.00
L7-M3	1343.00	125.29	1282.00	L7-M3	2481.80	159.77	1271.00
L7-M4	1353.30	157.79	1271.00	L7-M4	1338.20	167.63	1248.50
L7-M5	1295.60	88.47	1285.00	L7-M5	1274.30	80.85	1262.50
L7-M6	1295.50	106.43	1289.50	L7-M6	1269.80	84.35	1229.50
L8-M1	1328.60	110.64	1289.50	L8-M1	1399.40	181.88	1338.00
L8-M2	1413.30	102.35	1276.00	L8-M2	1620.40	150.76	1438.50

L8-M3	1304.50	107.65	1287.00	L8-M3	1428.20	168.57	1418.50
L8-M4	1338.90	138.61	1308.00	L8-M4	1469.80	190.11	1424.50
L8-M5	1296.90	111.39	1296.50	L8-M5	1474.00	161.07	1440.50
L8-M6	1307.40	152.64	1271.50	L8-M6	1493.40	194.08	1513.50
L9-M1	1385.00	147.43	1374.50	L9-M1	1490.90	123.71	1474.50
L9-M2	1347.80	133.78	1277.00	L9-M2	1430.60	184.16	1381.00
L9-M3	1395.50	144.39	1322.00	L9-M3	1469.90	151.51	1450.50
L9-M4	1377.60	172.57	1312.50	L9-M4	1462.40	147.96	1392.00
L9-M5	1421.00	147.93	1407.50	L9-M5	1464.70	135.19	1438.00
L9-M6	1423.30	180.68	1396.00	L9-M6	1465.70	183.03	1388.00
L10-M1	1352.20	106.60	1316.00	L10-M1	1353.90	78.71	1344.00
L10-M2	1381.10	108.46	1370.50	L10-M2	1366.20	93.56	1350.50
L10-M3	1404.10	120.83	1377.00	L10-M3	1399.00	94.45	1371.50
L10-M4	1396.20	143.84	1361.50	L10-M4	1404.40	108.42	1406.00
L10-M5	1411.20	114.00	1361.00	L10-M5	1394.40	102.12	1387.00
L10-M6	1408.30	128.90	1373.50	L10-M6	1410.30	112.48	1418.50

b. Mean, SD and median values of F2 (Hz) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ta/	Benchmark	1539.80	109.67	1528.50	/da/	Benchmark	1673.30	140.73	1663.00
	L1-M1	1567.00	92.47	1558.50		L1-M1	1584.30	99.76	1597.00
	L1-M2	1506.80	96.21	1480.50		L1-M2	1477.50	98.27	1475.50
	L1-M3	1525.70	89.92	1511.50		L1-M3	1537.50	189.37	1558.50
	L1-M4	1525.70	110.85	1518.00		L1-M4	1540.60	84.91	1559.00
	L1-M5	1470.70	191.81	1465.50		L1-M5	1542.40	106.22	1534.50
	L1-M6	1544.10	125.31	1547.00		L1-M6	1590.40	112.46	1595.50
	L2-M1	1476.10	108.86	1483.00		L2-M1	1195.70	136.69	1473.50
	L2-M2	1446.70	160.66	1491.00		L2-M2	1244.80	198.47	1511.00
	L2-M3	1474.90	167.00	1492.50		L2-M3	1175.60	145.61	1380.00

L2-M4	1498.10	117.20	1505.50	L2-M4	1175.90	156.23	1438.50
L2-M5	1478.40	128.76	1485.00	L2-M5	1218.50	156.30	1525.00
L2-M6	1487.90	142.23	1487.00	L2-M6	1209.30	54.41	1482.50
L3-M1	1500.10	99.50	1475.00	L3-M1	1505.70	38.67	1510.50
L3-M2	1471.70	101.64	1438.50	L3-M2	1354.30	81.23	1507.00
L3-M3	1430.50	109.92	1435.50	L3-M3	1539.40	126.00	1504.00
L3-M4	1460.30	104.92	1423.50	L3-M4	1541.80	121.74	1499.50
L3-M5	1468.30	87.56	1429.00	L3-M5	1567.80	107.18	1536.00
L3-M6	1481.40	91.72	1444.00	L3-M6	1535.40	89.09	1533.50
L4-M1	1495.30	139.51	1551.50	L4-M1	1578.40	161.31	1577.00
L4-M2	1494.50	179.78	1524.50	L4-M2	1607.40	186.97	1585.50
L4-M3	1480.20	147.87	1484.00	L4-M3	1544.00	176.85	1531.50
L4-M4	1487.60	150.11	1487.50	L4-M4	1607.30	129.81	1619.00
L4-M5	1449.70	124.18	1375.50	L4-M5	1550.20	174.86	1503.50
L4-M6	1427.90	165.27	1421.50	L4-M6	1581.00	157.06	1554.50
L5-M1	1468.90	105.66	1495.50	L5-M1	1619.00	120.80	1574.50
L5-M2	1477.50	141.76	1482.50	L5-M2	1634.50	141.44	1566.50
L5-M3	1496.90	113.70	1533.00	L5-M3	1645.00	132.50	1626.00
L5-M4	1494.70	105.09	1528.00	L5-M4	1629.30	154.78	1621.50
L5-M5	1463.50	118.76	1492.50	L5-M5	1607.90	130.79	1541.00
L5-M6	1486.60	130.68	1511.00	L5-M6	1623.20	125.31	1580.50
L6-M1	1503.90	122.04	1533.50	L6-M1	1505.50	147.89	1487.00
L6-M2	1464.40	98.64	1449.00	L6-M2	1478.40	136.73	1456.50
L6-M3	1489.00	94.244	1467.50	L6-M3	1523.20	125.20	1507.00
L6-M4	1472.70	127.08	1543.50	L6-M4	1529.10	131.94	1553.50
L6-M5	1424.10	113.34	1442.00	L6-M5	1525.00	128.05	1510.50
L6-M6	1480.40	113.16	1466.00	L6-M6	1573.30	146.33	1599.00
L7-M1	1292.00	82.75	1354.50	L7-M1	1378.40	99.54	1396.00
L7-M2	1360.10	152.55	1338.00	L7-M2	1369.90	123.59	1354.00
L7-M3	1321.30	128.35	1326.00	L7-M3	1371.70	133.25	1351.50

L7-M4	1345.00	100.60	1286.50	L7-M4	1521.40	151.45	1461.50
L7-M5	1364.60	135.32	1323.50	L7-M5	1401.90	119.26	1368.50
L7-M6	1330.00	114.09	1282.00	L7-M6	1356.60	80.25	1333.00
L8-M1	1368.10	121.64	1440.50	L8-M1	1447.70	145.79	1444.50
L8-M2	1344.50	163.84	1424.50	L8-M2	1593.00	130.09	1572.00
L8-M3	1348.60	160.29	1432.00	L8-M3	1465.30	206.81	1442.00
L8-M4	1366.10	148.92	1421.00	L8-M4	1446.90	186.98	1422.50
L8-M5	1404.30	169.46	1414.00	L8-M5	1450.70	220.27	1398.50
L8-M6	1358.60	139.24	1377.00	L8-M6	1530.90	168.62	1516.50
L9-M1	1364.70	167.74	1459.50	L9-M1	1536.20	112.09	1530.50
L9-M2	1376.80	178.01	1451.50	L9-M2	1545.70	85.48	1553.50
L9-M3	1330.10	168.90	1424.00	L9-M3	1550.20	120.88	1534.00
L9-M4	1422.50	204.65	1456.50	L9-M4	1573.10	103.61	1545.00
L9-M5	1334.90	163.70	1443.00	L9-M5	1604.70	101.70	1589.50
L9-M6	1342.20	175.89	1455.00	L9-M6	1588.80	118.00	1563.50
L10-M1	1423.90	130.56	1562.00	L10-M1	1594.10	153.67	1599.00
L10-M2	1442.30	137.07	1555.00	L10-M2	1586.40	181.07	1611.50
L10-M3	1478.70	131.18	1527.50	L10-M3	1625.40	154.55	1621.00
L10-M4	1458.70	121.20	1548.00	L10M4	1628.60	133.78	1592.50
L10-M5	1472.50	129.51	1535.50	L10-M5	1636.50	141.19	1598.50
L10-M6	1471.50	119.57	1534.50	L10-M6	1669.00	133.94	1662.00

c. Mean, SD and median values of F2 (Hz) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ka/	Benchmark	1471.40	115.35	1481.50	/ga/	Benchmark	1515.20	135.07	1540.50
	L1-M1	1456.40	162.15	1425.50		L1-M1	1472.20	216.66	1527.50
	L1-M2	1437.50	106.88	1447.50		L1-M2	1442.20	186.11	1481.50
	L1-M3	1464.40	95.29	1451.50		L1-M3	1521.60	85.08	1528.00
	L1-M4	1463.60	99.89	1446.50		L1-M4	1481.80	111.83	1503.00
	L1-M5	1444.80	118.27	1463.00		L1-M5	1494.10	103.22	1502.00

L1-M6	1488.70	114.87	1477.00	L1-M6	1510.60	100.68	1524.50
L2-M1	1410.30	116.45	1444.50	L2-M1	1067.20	148.03	1430.50
L2-M2	1510.70	154.81	1426.50	L2-M2	1249.30	105.41	1490.00
L2-M3	1359.50	133.57	1328.00	L2-M3	1113.00	100.98	1300.50
L2-M4	1363.40	147.05	1399.00	L2-M4	1112.60	111.10	1373.50
L2-M5	1419.80	135.33	1456.00	L2-M5	1181.70	136.23	1467.00
L2-M6	1430.20	141.36	1445.50	L2-M6	1149.40	116.74	1412.00
L3-M1	1428.10	84.15	1429.00	L3-M1	1281.20	163.02	1420.00
L3-M2	1392.40	99.38	1411.50	L3-M2	2581.30	156.17	1464.50
L3-M3	1391.60	93.52	1399.50	L3-M3	1349.90	199.71	1450.00
L3-M4	1404.90	81.95	1424.50	L3-M4	1468.10	146.24	1524.50
L3-M5	1402.90	93.29	1446.50	L3-M5	1498.60	152.77	1568.00
L3-M6	1418.20	104.37	1437.00	L3-M6	1477.80	145.07	1544.50
L4-M1	1460.10	108.41	1478.00	L4-M1	1501.00	160.99	1516.50
L4-M2	1493.00	131.48	1535.00	L4-M2	1513.30	179.10	1545.00
L4-M3	1471.80	177.03	1474.50	L4-M3	1514.70	219.64	1520.00
L4-M4	1465.70	141.80	1441.00	L4-M4	1516.80	192.51	1559.00
L4-M5	1453.20	116.13	1424.50	L4-M5	1446.90	169.11	1385.00
L4-M6	1461.20	142.11	1522.00	L4-M6	1460.70	179.81	1448.50
L5-M1	1473.00	83.90	1482.00	L5-M1	1547.50	115.98	1604.00
L5-M2	1472.40	77.26	1477.00	L5-M2	1575.40	143.06	1589.00
L5-M3	1475.30	104.24	1495.00	L5-M3	1586.00	141.01	1577.50
L5-M4	1473.20	98.95	1485.50	L5-M4	1534.70	143.00	1530.00
L5-M5	1493.10	103.52	1523.00	L5-M5	1555.40	152.64	1578.00
L5-M6	1476.60	105.70	1501.50	L5-M6	1532.30	152.82	1503.50
L6-M1	1449.50	123.53	1452.00	L6-M1	1490.00	131.32	1463.50
L6-M2	1432.20	89.63	1431.50	L6-M2	1456.90	179.20	1432.50
L6-M3	1397.30	117.40	1366.00	L6-M3	1527.30	92.06	1532.00
L6-M4	1472.70	127.08	1464.00	L6-M4	1506.80	156.99	1542.50
L6-M5	1424.10	113.34	1446.50	L6-M5	1526.60	151.06	1593.00

L6-M6	1480.40	113.16	1513.00	L6-M6	1547.70	130.65	1567.50
L7-M1	1292.00	82.75	1287.00	L7-M1	1342.20	117.58	1333.50
L7-M2	1360.10	152.55	1297.50	L7-M2	1403.40	125.15	1364.50
L7-M3	1321.30	128.35	1271.00	L7-M3	1440.80	191.16	1431.50
L7-M4	1345.00	100.60	1363.50	L7-M4	1376.20	108.28	1381.50
L7-M5	1364.60	135.32	1356.50	L7-M5	1408.80	150.59	1345.50
L7-M6	1330.00	114.09	1330.00	L7-M6	1422.20	186.20	1384.50
L8-M1	1368.10	121.64	1349.50	L8-M1	1356.50	99.59	1342.00
L8-M2	1344.50	163.84	1311.00	L8-M2	1545.20	187.42	1393.00
L8-M3	1348.60	160.29	1339.50	L8-M3	1427.70	174.03	1443.00
L8-M4	1366.10	148.92	1371.50	L8-M4	1410.40	107.32	1424.50
L8-M5	1404.30	169.46	1354.50	L8-M5	1394.10	127.78	1367.00
L8-M6	1358.60	139.24	1318.00	L8-M6	1437.70	178.52	1392.50
L9-M1	1364.70	167.74	1351.00	L9-M1	1447.20	122.20	1438.50
L9-M2	1376.80	178.01	1358.00	L9-M2	1488.60	93.84	1531.00
L9-M3	1330.10	168.90	1310.00	L9-M3	1486.70	108.00	1527.00
L9-M4	1422.50	204.65	1390.00	L9-M4	1478.50	116.37	1461.50
L9-M5	1334.90	163.70	1324.00	L9-M5	1474.80	194.44	1476.50
L9-M6	1342.20	175.89	1317.00	L9-M6	1515.60	147.10	1559.50
L10-M1	1423.90	130.57	1439.50	L10-M1	1480.40	147.75	1484.00
L10-M2	1442.30	137.07	1455.00	L10-M2	1506.40	151.12	1538.50
L10-M3	1478.70	131.18	1505.50	L10-M3	1516.10	142.44	1529.00
L10-M4	1458.70	121.20	1477.50	L10-M4	1521.30	135.12	1537.00
L10-M5	1472.50	129.51	1494.00	L10-M5	1530.40	141.64	1563.50
L10-M6	1471.50	119.57	1492.50	L10-M6	1523.10	132.81	1540.50

d. Mean, SD & median values of F2 (Hz) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	1494.10	123.64	1463.50	/dha/	Benchmark	1595.50	118.05	1602.00

L1-M1	1549.40	123.12	1493.00	L1-M1	1578.60	110.49	1569.50
L1-M2	1445.60	138.34	1432.00	L1-M2	1496.40	122.03	1444.00
L1-M3	1504.10	120.36	1468.50	L1-M3	1513.10	172.05	1545.00
L1-M4	1449.30	116.37	1437.00	L1-M4	1501.20	112.96	1496.50
L1-M5	1438.40	131.32	1445.00	L1-M5	1489.90	114.97	1500.50
L1-M6	1422.00	184.22	1453.00	L1-M6	1550.70	88.53	1535.00
L2-M1	1438.80	96.11	1460.00	L2-M1	1160.50	119.57	1434.50
L2-M2	1541.90	189.66	1510.50	L2-M2	1311.70	199.32	1520.00
L2-M3	1457.90	172.13	1488.00	L2-M3	1147.60	121.29	1387.00
L2-M4	1487.40	163.24	1502.50	L2-M4	1194.90	149.16	1461.00
L2-M5	1515.50	119.20	1500.50	L2-M5	1198.10	136.70	1439.50
L2-M6	1498.70	122.51	1514.50	L2-M6	1169.50	125.75	1383.00
L3-M1	1394.10	127.09	1416.00	L3-M1	1440.60	130.11	1457.00
L3-M2	1373.00	94.86	1360.00	L3-M2	1441.60	146.29	1436.50
L3-M3	1377.50	101.19	1372.00	L3-M3	1430.20	170.33	1414.00
L3-M4	1348.30	79.48	1342.00	L3-M4	1485.70	149.98	1482.50
L3-M5	1414.20	136.78	1415.00	L3-M5	1512.70	135.91	1514.50
L3-M6	1416.50	98.88	1423.00	L3-M6	1435.90	145.04	1371.50
L4-M1	1466.00	144.24	1444.00	L4-M1	1553.90	146.70	1552.00
L4-M2	1476.40	179.88	1483.00	L4-M2	1554.40	189.28	1540.00
L4-M3	1459.70	159.50	1451.50	L4-M3	1513.60	175.57	1501.00
L4-M4	1419.40	180.85	1353.50	L4-M4	1497.20	163.32	1472.50
L4-M5	1474.40	152.55	1438.50	L4-M5	1517.20	204.17	1497.00
L4-M6	1423.30	134.17	1390.00	L4-M6	1488.50	200.68	1466.00
L5-M1	1511.20	74.63	1510.00	L5-M1	1531.50	104.28	1521.50
L5-M2	1493.60	101.75	1471.50	L5-M2	1536.40	96.22	1532.00
L5-M3	1513.20	75.55	1491.00	L5-M3	1537.00	127.82	1519.50
L5-M4	1512.60	123.22	1479.00	L5-M4	1537.20	117.29	1566.00
L5-M5	1535.10	116.76	1511.50	L5-M5	1537.40	115.39	1541.00
L5-M6	1524.80	125.53	1496.00	L5-M6	1545.40	126.63	1568.50

L6-M1	1476.40	109.35	1459.50	L6-M1	1505.30	120.36	1456.00
L6-M2	1456.90	106.45	1451.50	L6-M2	1455.20	60.78	1443.50
L6-M3	1479.00	101.77	1502.00	L6-M3	1512.70	122.36	1519.50
L6-M4	1464.30	142.11	1476.50	L6-M4	1544.60	82.21	1533.00
L6-M5	1480.80	99.83	1461.00	L6-M5	1533.30	103.63	1519.00
L6-M6	1510.00	119.45	1500.50	L6-M6	1546.40	80.66	1556.00
L7-M1	1474.80	137.63	1374.50	L7-M1	1414.00	116.77	1394.00
L7-M2	1378.30	160.87	1333.50	L7-M2	1397.40	143.75	1374.50
L7-M3	1452.80	197.30	1442.50	L7-M3	1419.00	114.40	1408.50
L7-M4	1378.40	71.32	1392.50	L7-M4	1435.60	118.37	1412.50
L7-M5	1364.90	110.30	1402.50	L7-M5	1393.90	144.75	1347.00
L7-M6	1336.20	105.49	1305.00	L7-M6	1407.70	124.62	1362.00
L8-M1	1516.60	219.81	1459.00	L8-M1	1509.00	224.14	1488.00
L8-M2	1553.40	223.191	1561.00	L8-M2	1662.30	174.21	1585.50
L8-M3	1499.50	190.95	1440.00	L8-M3	1533.60	205.75	1600.50
L8-M4	1509.90	208.23	1438.00	L8-M4	1510.60	224.16	1507.00
L8-M5	1523.70	184.29	1498.50	L8-M5	1599.90	133.69	1549.50
L8-M6	1489.70	232.77	1456.00	L8-M6	1528.30	224.30	1563.00
L9-M1	1534.90	167.91	1470.50	L9-M1	2833.90	121.86	1504.50
L9-M2	1509.30	152.55	1505.50	L9-M2	1546.90	93.75	1572.00
L9-M3	1521.50	146.97	1499.50	L9-M3	1576.90	96.25	1574.50
L9-M4	1539.70	138.96	1522.00	L9-M4	1539.30	151.22	1562.00
L9-M5	1531.90	148.33	1480.00	L9-M5	1574.20	101.69	1569.50
L9-M6	1551.60	144.01	1586.50	L9-M6	1589.80	103.39	1583.50
L10-M1	1475.20	144.05	1460.50	L10-M1	1582.50	136.33	1573.00
L10-M2	1514.50	122.76	1489.00	L10-M2	3125.60	100.17	1635.50
L10-M3	1498.10	112.26	1466.00	L10-M3	1506.60	130.84	1562.00
L10-M4	1505.90	115.47	1467.00	L10-M4	1607.30	141.30	1624.00
L10-M5	1521.20	126.22	1488.00	L10-M5	1606.70	127.47	1609.00
L10-M6	1490.50	124.90	1448.00	L10-M6	1602.90	126.90	1597.50

Table 8

a. Mean, SD & median values of VOT (msec) for sounds /pa/ and /ba/ for different recording combinations

Sound	Configuration	Mean	SD	Median	Sound	Configuration	Mean	SD	Median
/pa/	Benchmark	22.78	4.790	23	/ba/	Benchmark	131.00	24.031	127.00
	L1-M1	21.67	5.123	23		L1-M1	121.78	35.177	110.00
	L1-M2	24.67	4.975	24		L1-M2	119.67	39.000	110.00
	L1-M3	21.22	3.492	22		L1-M3	112.67	32.241	110.00
	L1-M4	20.33	9.644	20		L1-M4	107.78	54.648	100.00
	L1-M5	21.22	4.790	22		L1-M5	114.89	31.829	114.00
	L1-M6	21.33	4.183	21		L1-M6	112.00	28.111	99.00
	L2-M1	16.00	9.447	15		L2-M1	102.22	46.840	109.00
	L2-M2	24.22	4.060	22		L2-M2	106.56	36.278	105.00
	L2-M3	23.00	6.000	24		L2-M3	101.44	57.542	106.00
	L2-M4	23.44	8.237	24		L2-M4	101.44	56.179	102.00
	L2-M5	24.22	3.590	22		L2-M5	101.11	52.193	102.00
	L2-M6	24.33	5.840	21		L2-M6	105.89	60.458	101.00
	L3-M1	14.22	7.710	15		L3-M1	86.00	58.282	92.00
	L3-M2	10.78	6.058	12		L3-M2	92.33	49.997	86.00
	L3-M3	13.78	4.295	15		L3-M3	98.00	49.158	94.00
	L3-M4	12.67	6.344	13		L3-M4	91.22	42.266	88.00
	L3-M5	10.67	6.344	13		L3-M5	66.11	56.313	72.00
	L3-M6	12.22	7.645	16		L3-M6	70.67	64.250	72.00
	L4-M1	23.11	7.201	21		L4-M1	106.00	34.300	98.00
	L4-M2	21.67	5.268	24		L4-M2	97.00	33.560	84.00
	L4-M3	20.00	6.481	20		L4-M3	95.78	29.563	92.00
	L4-M4	22.11	5.302	22		L4-M4	100.67	33.690	90.00

L4-M5	20.11	5.036	20	L4-M5	101.22	34.430	102.00
L4-M6	21.00	4.899	21	L4-M6	97.89	21.894	92.00
L5-M1	20.56	6.327	21	L5-M1	99.78	19.169	91.00
L5-M2	18.78	5.932	16	L5-M2	105.89	29.868	92.00
L5-M3	19.67	8.689	16	L5-M3	109.67	32.749	93.00
L5-M4	20.33	6.928	21	L5-M4	103.00	33.027	88.00
L5-M5	18.89	5.925	19	L5-M5	100.11	25.047	89.00
L5-M6	19.89	6.333	23	L5-M6	106.56	23.880	99.00
L6-M1	17.11	3.790	18	L6-M1	114.33	20.463	118.00
L6-M2	20.56	3.609	21	L6-M2	113.67	33.253	112.00
L6-M3	18.33	2.784	18	L6-M3	118.22	28.190	109.00
L6-M4	18.44	4.876	18	L6-M4	103.89	23.725	93.00
L6-M5	19.44	2.651	19	L6-M5	97.89	35.547	102.00
L6-M6	20.67	3.000	20	L6-M6	111.89	27.926	99.00
L7-M1	22.11	2.892	23	L7-M1	109.00	23.511	105.00
L7-M2	19.33	8.396	21	L7-M2	94.56	39.589	102.00
L7-M3	20.44	5.077	21	L7-M3	101.78	16.873	102.00
L7-M4	19.11	1.691	19	L7-M4	103.67	19.849	106.00
L7-M5	20.22	4.764	22	L7-M5	104.89	20.040	96.00
L7-M6	19.22	8.333	22	L7-M6	106.00	19.919	100.00
L8-M1	21.44	9.876	25	L8-M1	83.89	35.445	85.00
L8-M2	16.11	11.308	18	L8-M2	81.67	35.479	93.00
L8-M3	15.22	9.576	16	L8-M3	79.67	35.927	86.00
L8-M4	16.33	10.689	18	L8-M4	102.78	26.362	105.00
L8-M5	12.89	10.671	16	L8--M5	89.44	39.538	93.00
L8-M6	15.78	12.863	19	L8-M6	84.11	35.077	85.00
L9-M1	19.44	5.457	20	L9-M1	104.11	20.214	99.00
L9-M2	19.44	4.773	20	L9-M2	104.78	19.823	103.00
L9-M3	19.89	5.578	20	L9-M3	100.78	19.227	98.00
L9-M4	20.00	5.244	20	L9-M4	105.33	21.378	109.00

L9-M5	18.78	3.153	18	L9-M5	108.78	20.957	116.00
L9-M6	20.67	3.905	20	L9-M6	105.67	19.410	96.00
L10-M1	20.11	3.333	21	L10-M1	109.56	21.892	118.00
L10-M2	24.22	4.466	23	L10-M2	115.11	22.161	124.00
L10-M3	23.22	2.863	23	L10-M3	110.33	20.310	105.00
L10-M4	25.67	2.739	27	L10-M4	107.00	21.407	98.00
L10-M5	23.11	4.076	24	L10-M5	111.00	18.248	109.00
L10-M6	23.00	4.500	23	L10-M6	114.00	13.964	110.00

b. Mean, SD & median values of VOT (msec) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ta/	Benchmark	23.30	2.710	23.50	/da/	Benchmark	137.56	29.039	130.00
	L1-M1	22.50	4.116	23.50		L1-M1	122.00	29.912	118.00
	L1-M2	20.80	3.967	22.00		L1-M2	115.89	30.399	115.00
	L1-M3	20.90	4.677	22.00		L1-M3	123.44	31.021	115.00
	L1-M4	21.10	10.093	21.00		L1-M4	113.22	54.836	105.00
	L1-M5	21.60	3.978	23.00		L1-M5	125.67	31.488	120.00
	L1-M6	21.40	4.926	21.50		L1-M6	122.00	34.533	120.00
	L2-M1	22.70	8.616	22.50		L2-M1	133.22	32.986	109.00
	L2-M2	20.80	10.250	24.00		L2-M2	131.22	38.372	116.00
	L2-M3	20.10	9.723	21.50		L2-M3	131.11	36.723	112.00
	L2-M4	22.80	10.174	24.00		L2-M4	137.89	34.003	112.00
	L2-M5	21.00	10.614	24.00		L2-M5	131.11	37.582	126.00
	L2-M6	20.40	4.812	20.00		L2-M6	130.11	39.220	121.00
	L3-M1	15.30	8.097	16.00		L3-M1	93.78	58.800	104.00
	L3-M2	15.00	7.732	15.00		L3-M2	70.56	56.939	91.00
	L3-M3	15.00	4.028	16.50		L3-M3	95.89	54.349	90.00
	L3-M4	14.80	6.877	16.00		L3-M4	78.11	48.282	95.00

L3-M5	12.10	6.064	12.50	L3-M5	68.78	55.452	82.00
L3-M6	10.10	7.264	12.50	L3-M6	67.89	55.748	81.00
L4-M1	18.00	8.327	17.00	L4-M1	118.67	37.726	129.00
L4-M2	22.40	8.127	20.50	L4-M2	117.78	31.999	115.00
L4-M3	19.40	5.168	17.50	L4-M3	102.00	36.725	106.00
L4-M4	20.40	7.351	19.50	L4-M4	108.11	33.449	95.00
L4-M5	19.80	6.143	18.50	L4-M5	112.22	37.225	121.00
L4-M6	19.70	5.012	18.00	L4-M6	109.56	25.846	115.00
L5-M1	19.60	5.967	20.00	L5-M1	124.33	28.935	127.00
L5-M2	20.20	4.185	21.00	L5-M2	127.56	26.898	120.00
L5-M3	20.00	6.307	20.50	L5-M3	129.00	20.676	125.00
L5-M4	21.50	4.859	22.50	L5-M4	130.67	38.849	123.00
L5-M5	21.10	4.909	21.00	L5-M5	122.56	33.549	120.00
L5-M6	20.60	10.135	23.50	L5-M6	118.11	22.138	120.00
L6-M1	18.80	4.614	19.00	L6-M1	125.00	28.205	119.00
L6-M2	19.50	4.478	19.00	L6-M2	125.00	28.579	119.00
L6-M3	20.20	4.442	19.00	L6-M3	120.11	25.722	110.00
L6-M4	19.30	3.945	20.00	L6-M4	172.33	169.000	125.00
L6-M5	18.20	2.150	18.00	L6-M5	111.56	39.724	118.00
L6-M6	18.80	3.706	19.00	L6-M6	125.56	27.318	121.00
L7-M1	19.90	4.771	19.00	L7-M1	115.44	24.643	114.00
L7-M2	16.90	7.355	18.00	L7-M2	105.44	45.365	119.00
L7-M3	17.40	4.351	18.50	L7-M3	118.22	26.133	121.00
L7-M4	17.50	2.461	18.00	L7-M4	119.67	27.996	121.00
L7-M5	17.00	4.000	18.50	L7-M5	119.56	20.427	119.00
L7-M6	18.20	2.741	18.00	L7-M6	118.00	21.697	120.00
L8-M1	26.20	10.293	27.00	L8-M1	84.78	35.556	92.00
L8-M2	24.20	11.153	25.50	L8-M2	82.11	34.181	92.00
L8-M3	20.70	8.920	22.50	L8-M3	83.33	35.235	86.00
L8-M4	22.90	9.983	22.00	L8-M4	81.33	35.415	86.00

L8-M5	23.10	9.758	24.50	L8-M5	93.67	24.285	87.00
L8-M6	23.30	9.604	24.00	L8-M6	84.67	37.577	89.00
L9-M1	21.60	3.893	20.50	L9-M1	107.33	20.304	110.00
L9-M2	21.60	4.648	21.50	L9-M2	110.22	26.748	112.00
L9-M3	22.80	2.300	23.00	L9-M3	110.33	20.706	109.00
L9-M4	21.10	3.957	21.00	L9-M4	111.11	19.245	110.00
L9-M5	19.90	4.067	19.50	L9--M5	113.89	26.403	119.00
L9-M6	20.90	3.900	21.00	L9-M6	113.33	19.717	110.00
L10-M1	19.40	4.858	19.50	L10-M1	126.11	14.066	124.00
L10-M2	20.20	4.826	19.50	L10-M2	120.67	20.609	129.00
L10-M3	17.40	3.273	17.00	L10-M3	129.67	24.109	132.00
L10-M4	19.90	3.929	18.50	L10-M4	125.44	19.262	126.00
L10-M5	15.90	3.414	16.00	L10-M5	128.00	16.591	134.00
L10-M6	16.00	3.432	15.50	L10-M6	126.33	20.512	134.00

c. Mean, SD & median values of VOT (msec) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ka/	Benchmark	43.70	8.564	41.50	/ga/	Benchmark	144.11	27.989	130.00
	L1-M1	39.20	8.430	40.50		L1-M1	136.56	32.207	139.00
	L1-M2	42.20	11.203	40.50		L1-M2	143.00	44.595	123.00
	L1-M3	40.00	7.071	41.50		L1-M3	134.67	41.743	135.00
	L1-M4	37.50	13.938	42.00		L1-M4	117.22	55.581	128.00
	L1-M5	39.80	6.795	40.00		L1-M5	121.56	30.266	121.00
	L1-M6	43.30	8.820	44.00		L1-M6	131.56	29.577	139.00
	L2-M1	32.80	7.147	36.50		L2-M1	132.89	33.128	110.00
	L2-M2	39.60	8.815	35.50		L2-M2	132.67	33.243	105.00
	L2-M3	38.80	8.659	35.00		L2-M3	133.44	39.913	130.00
	L2-M4	33.60	8.115	40.50		L2-M4	135.11	31.260	120.00

L2-M5	37.50	7.932	31.50	L2-M5	139.33	35.595	120.00
L2-M6	36.60	7.486	39.00	L2-M6	130.67	34.339	105.00
L3-M1	25.90	11.229	31.00	L3-M1	97.56	64.119	115.00
L3-M2	21.90	13.203	25.00	L3-M2	79.11	68.617	92.00
L3-M3	29.50	11.928	34.00	L3-M3	93.67	41.219	100.00
L3-M4	30.60	6.786	32.00	L3-M4	85.44	52.958	92.00
L3-M5	21.90	15.538	29.00	L3-M5	79.11	67.649	96.00
L3-M6	22.70	15.720	31.00	L3-M6	74.33	63.928	91.00
L4-M1	30.70	11.156	33.00	L4-M1	124.00	47.247	105.00
L4-M2	43.30	12.667	41.50	L4-M2	110.44	39.919	94.00
L4-M3	38.90	9.279	38.00	L4-M3	119.11	43.109	100.00
L4-M4	42.10	14.051	40.00	L4-M4	99.89	58.407	94.00
L4-M5	39.30	10.371	36.00	L4-M5	111.78	53.976	90.00
L4-M6	37.00	8.287	35.00	L4-M6	116.67	44.660	100.00
L5-M1	42.20	8.967	39.00	L5-M1	126.89	35.456	118.00
L5-M2	44.70	10.034	43.50	L5-M2	125.67	25.120	120.00
L5-M3	44.40	10.648	42.00	L5-M3	131.22	35.912	113.00
L5-M4	45.80	8.600	44.50	L5-M4	122.89	30.665	115.00
L5-M5	44.70	9.534	45.50	L5-M5	122.00	26.434	114.00
L5-M6	41.80	8.574	41.50	L5-M6	130.78	43.124	125.00
L6-M1	38.20	10.758	33.50	L6-M1	132.00	45.056	116.00
L6-M2	39.20	9.426	38.00	L6-M2	128.00	45.092	114.00
L6-M3	36.40	6.603	35.00	L6-M3	120.44	33.764	110.00
L6-M4	37.40	7.168	36.00	L6-M4	130.11	35.158	115.00
L6-M5	36.10	5.527	35.50	L6-M5	125.78	29.316	119.00
L6-M6	37.10	8.634	39.00	L6-M6	121.44	35.651	119.00
L7--M1	35.30	9.105	37.50	L7-M1	121.56	26.908	116.00
L7-M2	33.20	13.588	38.00	L7-M2	111.78	47.843	124.00
L7-M3	37.00	6.342	35.50	L7-M3	119.11	28.029	112.00
L7-M4	36.40	6.450	38.50	L7-M4	111.00	30.859	119.00

L7-M5	36.80	6.596	36.00	L7-M5	117.44	21.331	121.00
L7-M6	31.30	12.347	33.50	L7-M6	114.33	35.221	116.00
L8-M1	35.50	6.604	33.50	L8-M1	92.89	37.435	100.00
L8-M2	32.30	12.588	35.50	L8-M2	96.78	40.413	100.00
L8-M3	27.60	15.378	34.00	L8-M3	94.00	41.785	95.00
L8-M4	37.10	6.315	36.50	L8-M4	110.44	20.440	103.00
L8-M5	33.80	6.339	33.50	L8-M5	105.11	19.394	110.00
L8-M6	33.00	12.570	36.00	L8-M6	99.56	41.476	120.00
L9-M1	38.80	5.959	38.00	L9-M1	113.44	22.639	110.00
L9-M2	38.70	6.499	38.50	L9-M2	114.89	35.346	112.00
L9-M3	37.60	5.967	38.00	L9-M3	114.00	19.177	115.00
L9-M4	39.10	9.219	39.00	L9-M4	113.11	14.260	114.00
L9-M5	38.10	6.935	38.00	L9-M5	118.67	21.231	118.00
L9-M6	37.40	6.467	36.50	L9-M6	112.11	19.193	116.00
L10-M1	33.40	7.351	33.00	L10-M1	115.44	30.075	112.00
L10-M2	35.40	8.127	37.50	L10-M2	118.00	20.384	124.00
L10-M3	36.90	9.207	39.00	L10-M3	125.56	13.639	125.00
L10-M4	36.00	10.209	37.00	L10-M4	124.22	26.664	116.00
L10-M5	36.70	7.987	35.50	L10-M5	116.56	24.141	119.00
L10-M6	36.20	8.417	35.00	L10-M6	122.67	25.015	132.00

d. Mean, SD & median values of VOT (msec) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	25.00	4.190	26.00	/dha/	Benchmark	122.67	15.025	125.00
	L1-M1	24.30	6.430	25.00		L1-M1	122.56	28.276	127.00
	L1-M2	24.50	5.421	24.00		L1-M2	121.00	38.266	140.00
	L1-M3	23.90	6.707	24.50		L1-M3	108.33	29.606	100.00
	L1-M4	23.70	10.833	24.00		L1-M4	102.22	54.242	100.00

L1-M5	23.20	5.673	23.00	L1-M5	103.67	28.862	94.00
L1-M6	24.00	3.621	24.50	L1-M6	111.00	28.531	120.00
L2-M1	22.00	8.576	24.50	L2-M1	101.89	29.819	105.00
L2-M2	22.50	3.569	25.50	L2-M2	100.11	27.612	100.00
L2-M3	21.30	6.067	25.00	L2-M3	100.78	23.376	105.00
L2-M4	25.50	4.178	20.00	L2-M4	104.33	22.056	105.00
L2-M5	21.10	3.905	25.00	L2-M5	107.67	29.982	106.00
L2-M6	21.50	4.036	20.50	L2-M6	101.67	21.081	109.00
L3-M1	14.30	6.617	15.50	L3-M1	81.11	51.898	92.00
L3-M2	13.60	8.289	15.00	L3-M2	66.22	56.650	72.00
L3-M3	15.60	7.734	19.00	L3-M3	88.44	42.755	91.00
L3-M4	17.00	7.732	17.50	L3-M4	74.44	49.462	78.00
L3-M5	13.90	8.900	17.50	L3-M5	71.22	67.225	71.00
L3-M6	13.10	8.608	16.50	L3-M6	67.56	60.539	66.00
L4-M1	21.50	12.554	21.00	L4-M1	99.33	37.547	78.00
L4-M2	26.00	9.933	23.50	L4-M2	104.44	42.356	94.00
L4-M3	23.80	5.245	23.00	L4-M3	110.11	38.944	106.00
L4-M4	25.10	8.048	24.00	L4-M4	110.22	33.600	98.00
L4-M5	27.00	10.242	25.50	L4-M5	108.22	40.583	112.00
L4-M6	24.60	7.043	24.00	L4-M6	111.89	31.798	112.00
L5-M1	21.00	4.830	21.00	L5-M1	110.56	29.484	99.00
L5-M2	23.20	7.843	23.50	L5-M2	102.11	26.774	100.00
L5-M3	23.00	5.312	23.00	L5-M3	112.00	22.886	112.00
L5-M4	23.60	5.147	25.00	L5-M4	112.44	34.008	107.00
L5-M5	21.70	4.270	22.00	L5-M5	110.11	33.780	95.00
L5-M6	22.50	5.968	25.00	L5-M6	107.33	15.564	105.00
L6-M1	21.00	4.082	20.50	L6-M1	117.22	26.229	116.00
L6-M2	23.20	8.176	21.00	L6-M2	114.89	32.655	98.00
L6-M3	22.30	5.376	21.50	L6-M3	111.44	26.917	106.00
L6-M4	22.70	3.057	22.50	L6-M4	107.33	23.654	104.00

L6-M5	23.00	4.546	24.00	L6-M5	98.22	33.267	96.00
L6-M6	20.20	2.936	21.00	L6-M6	115.33	35.366	106.00
L7-M1	21.10	4.864	21.00	L7-M1	107.44	13.427	101.00
L7-M2	19.30	7.454	20.50	L7-M2	96.89	39.200	98.00
L7-M3	21.60	4.742	23.00	L7-M3	106.22	18.754	106.00
L7-M4	23.00	4.595	23.00	L7-M4	108.56	24.653	106.00
L7-M5	21.20	4.131	21.50	L7-M5	105.67	16.279	113.00
L7-M6	19.60	2.757	19.50	L7-M6	96.00	37.091	105.00
L8-M1	18.40	2.716	19.00	L8-M1	78.89	30.477	90.00
L8-M2	19.20	7.700	20.50	L8-M2	67.78	33.211	80.00
L8-M3	19.00	7.040	20.50	L8-M3	71.56	33.664	85.00
L8-M4	20.70	3.057	20.00	L8-M4	97.67	24.233	92.00
L8-M5	19.30	6.993	21.50	L8-M5	84.67	15.215	75.00
L8-M6	19.20	6.893	21.00	L8-M6	78.00	29.912	85.00
L9-M1	22.60	2.066	23.00	L9-M1	104.22	20.241	110.00
L9-M2	22.10	3.929	22.00	L9-M2	103.89	22.992	100.00
L9-M3	21.90	3.348	21.00	L9-M3	104.22	19.428	105.00
L9-M4	21.30	4.809	19.50	L9-M4	102.56	19.132	98.00
L9-M5	21.00	2.494	20.50	L9-M5	99.00	20.006	95.00
L9-M6	22.90	3.381	22.50	L9-M6	102.33	19.255	105.00
L10-M1	21.40	4.142	21.50	L10-M1	114.22	9.324	112.00
L10-M2	22.60	4.006	21.00	L10-M2	119.00	20.779	119.00
L10-M3	22.30	1.636	23.00	L10-M3	121.00	22.798	120.00
L10-M4	22.80	2.700	23.00	L10-M4	115.56	21.881	114.00
L10-M5	22.30	2.111	22.50	L10-M5	119.89	13.560	116.00
L10-M6	25.10	2.726	24.50	L10-M6	109.44	7.568	109.00

Table 9

a. Mean, median & SD of closure duration (msec) for sounds /pa/ and /ba/ for different recording *combinations*

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/pa/	Benchmark	131.90	13.892	132.50	/ba/	Benchmark	98.30	16.567	98.50
	L1-M1	121.20	19.674	120.00		L1-M1	100.00	14.682	100.50
	L1-M2	115.50	31.694	112.50		L1-M2	92.90	23.077	89.00
	L1-M3	107.80	15.419	107.50		L1-M3	86.40	17.199	87.00
	L1-M4	104.30	21.623	100.50		L1-M4	79.40	22.041	74.50
	L1-M5	105.60	19.918	112.50		L1-M5	84.50	18.899	83.00
	L1-M6	115.50	13.834	119.00		L1-M6	90.40	13.032	87.00
	L2-M1	128.00	26.858	117.50		L2-M1	92.40	26.150	83.00
	L2-M2	127.90	27.233	121.00		L2-M2	91.60	24.985	98.50
	L2-M3	125.50	19.529	117.50		L2-M3	91.50	27.040	90.50
	L2-M4	117.80	24.229	106.00		L2-M4	92.10	23.168	89.00
	L2-M5	125.90	22.093	122.00		L2-M5	96.00	21.213	95.50
	L2-M6	124.00	23.362	117.50		L2-M6	89.00	21.034	90.50
	L3-M1	109.80	20.525	102.50		L3-M1	85.90	15.184	81.00
	L3-M2	113.40	14.408	113.50		L3-M2	75.50	30.233	75.50
	L3-M3	112.90	13.715	111.50		L3-M3	92.00	17.594	87.50
	L3-M4	113.40	26.124	107.50		L3-M4	89.80	15.971	86.00
	L3-M5	116.20	22.449	113.50		L3-M5	91.70	24.028	83.00
	L3-M6	119.30	29.189	112.50		L3-M6	90.30	20.950	79.00
	L4-M1	119.00	21.323	118.00		L4-M1	89.80	21.133	87.50
	L4-M2	119.50	20.046	121.00		L4-M2	86.50	17.940	88.50
	L4-M3	117.30	14.922	115.00		L4-M3	83.90	14.456	83.50
	L4-M4	124.80	17.887	124.50		L4-M4	88.90	19.559	90.50
	L4-M5	122.00	17.133	124.00		L4-M5	91.80	17.242	91.50
	L4-M6	119.10	20.755	121.50		L4-M6	89.70	15.713	89.00
	L5-M1	104.50	21.057	99.00		L5-M1	77.30	15.499	75.50
	L5-M2	98.20	15.419	95.00		L5-M2	74.20	15.368	71.00
	L5-M3	103.60	16.460	98.00		L5-M3	73.20	15.676	69.50

L5-M4	104.70	18.709	105.00	L5-M4	77.80	13.373	78.00
L5-M5	108.20	14.359	112.00	L5-M5	78.60	15.123	76.50
L5-M6	109.60	16.126	110.00	L5-M6	77.00	13.864	78.00
L6-M1	95.60	23.519	90.00	L6-M1	73.20	21.301	63.50
L6-M2	90.60	16.195	87.00	L6-M2	68.20	14.006	63.50
L6-M3	94.30	20.483	90.00	L6-M3	68.50	17.096	62.00
L6-M4	100.20	23.117	100.50	L6-M4	70.20	16.478	67.50
L6-M5	99.30	15.535	94.00	L6-M5	74.90	15.624	74.00
L6-M6	101.40	20.903	99.00	L6-M6	75.00	12.445	75.50
L7-M1	87.90	6.082	87.00	L7-M1	71.20	7.406	72.50
L7-M2	89.10	8.478	88.00	L7-M2	72.80	6.512	73.50
L7-M3	89.60	9.082	90.00	L7-M3	71.70	10.328	72.00
L7-M4	85.20	10.549	86.00	L7-M4	69.90	9.195	66.50
L7-M5	94.20	11.516	93.00	L7-M5	73.80	9.247	74.50
L7-M6	97.30	9.464	96.00	L7-M6	75.90	6.607	73.50
L8-M1	91.10	19.496	83.50	L8-M1	75.60	13.260	72.00
L8-M2	97.10	21.216	91.00	L8-M2	77.80	11.896	74.50
L8-M3	93.20	14.786	91.50	L8-M3	76.70	12.988	77.00
L8-M4	94.70	25.404	88.00	L8-M4	76.40	13.802	71.00
L8-M5	98.20	17.479	91.50	L8-M5	81.60	14.370	81.00
L8-M6	97.90	16.319	95.00	L8-M6	81.60	11.843	79.00
L9-M1	87.30	13.267	83.50	L9-M1	76.20	7.406	78.00
L9-M2	84.70	12.824	82.00	L9-M2	74.40	8.784	76.50
L9-M3	84.00	8.692	82.00	L9-M3	73.40	7.619	74.00
L9-M4	87.10	14.866	82.00	L9-M4	74.10	8.359	74.00
L9-M5	87.30	10.144	86.00	L9-M5	74.60	8.746	74.50
L9-M6	90.60	13.509	86.50	L9-M6	74.80	7.162	74.00
L10-M1	89.50	5.318	88.00	L10-M1	76.20	3.458	77.00
L10-M2	92.60	4.427	93.00	L10-M2	77.40	3.534	79.00
L10-M3	90.30	5.012	91.00	L10-M3	77.20	3.824	76.50

L10-M4	90.10	5.666	90.00	L10-M4	77.40	1.955	77.50
L10-M5	89.10	4.202	88.50	L10-M5	76.10	2.283	76.50
L10-M6	89.20	3.853	90.00	L10-M6	76.90	2.726	77.50

b. Mean, median and SD of closure duration (msec) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ta/	Benchmark	116.00	15.804	119.00	/da/	Benchmark	80.80	14.733	81.50
	L1-M1	104.90	19.313	104.50		L1-M1	76.20	19.860	75.00
	L1-M2	103.10	31.203	96.00		L1-M2	70.80	16.390	73.50
	L1-M3	97.40	18.769	100.00		L1-M3	67.00	14.438	69.00
	L1-M4	98.50	23.477	96.00		L1-M4	62.40	15.313	56.50
	L1-M5	94.40	16.972	95.00		L1-M5	68.00	15.528	66.00
	L1-M6	99.30	14.637	102.50		L1-M6	75.50	12.367	73.50
	L2-M1	112.20	36.337	104.00		L2-M1	75.60	14.253	73.50
	L2-M2	117.10	32.299	111.00		L2-M2	69.80	23.583	58.00
	L2-M3	114.50	27.110	107.50		L2-M3	70.10	22.980	69.50
	L2-M4	114.40	26.776	107.50		L2-M4	71.40	22.077	66.00
	L2-M5	115.30	26.111	110.00		L2-M5	78.30	26.634	82.50
	L2-M6	114.60	19.867	110.50		L2-M6	74.70	22.959	68.50
	L3-M1	100.90	23.905	94.50		L3-M1	76.90	15.154	73.00
	L3-M2	106.40	16.447	104.50		L3-M2	67.50	27.734	68.00
	L3-M3	107.40	21.345	99.50		L3-M3	77.00	16.472	71.50
	L3-M4	104.20	25.315	96.50		L3-M4	74.90	13.731	72.00
	L3-M5	104.80	22.275	97.50		L3-M5	82.20	22.543	75.50
	L3-M6	108.20	26.165	102.00		L3-M6	75.80	17.523	69.50
	L4-M1	106.10	22.649	103.00		L4-M1	64.00	16.000	70.00
	L4-M2	109.30	17.814	112.00		L4-M2	66.90	16.676	67.00
	L4-M3	104.30	20.045	109.00		L4-M3	62.20	13.887	61.50
	L4-M4	109.50	19.202	107.50		L4-M4	68.60	20.018	65.00

L4-M5	109.20	19.915	112.00	L4-M5	70.30	19.038	70.00
L4-M6	106.80	18.079	108.50	L4-M6	74.20	16.659	69.50
L5-M1	92.60	22.446	94.00	L5-M1	65.80	14.203	64.00
L5-M2	88.90	21.860	83.50	L5-M2	62.30	12.850	61.00
L5-M3	93.00	23.324	82.00	L5-M3	60.30	13.704	58.00
L5-M4	96.10	27.041	96.00	L5-M4	65.80	14.928	66.00
L5-M5	92.40	20.967	96.00	L5-M5	67.00	13.671	66.00
L5-M6	94.50	19.884	93.50	L5-M6	63.10	12.270	62.50
L6-M1	82.30	23.257	74.00	L6-M1	58.10	11.733	52.50
L6-M2	79.40	20.299	73.50	L6-M2	56.40	11.237	54.00
L6-M3	85.80	22.049	75.00	L6-M3	57.50	16.036	51.00
L6-M4	85.90	25.632	84.50	L6-M4	59.90	14.851	56.50
L6-M5	88.20	16.982	85.00	L6-M5	64.50	11.569	63.00
L6-M6	91.80	20.531	85.00	L6-M6	64.80	13.198	66.00
L7-M1	78.00	8.219	76.00	L7-M1	62.80	7.005	62.50
L7-M2	80.60	8.644	80.50	L7-M2	63.50	5.662	63.50
L7-M3	80.70	9.166	77.00	L7-M3	61.10	10.482	61.00
L7-M4	80.60	7.734	80.00	L7-M4	61.60	9.698	60.50
L7-M5	84.00	11.411	84.50	L7-M5	67.50	8.772	67.50
L7-M6	86.80	10.932	88.00	L7-M6	66.80	9.705	66.00
L8-M1	83.90	18.387	76.00	L8-M1	71.20	11.094	73.50
L8-M2	88.30	22.251	83.00	L8-M2	64.70	23.870	67.00
L8-M3	87.20	19.470	82.00	L8-M3	73.30	12.093	71.50
L8-M4	84.80	21.400	80.00	L8-M4	70.90	13.601	68.00
L8-M5	90.60	17.828	84.50	L8-M5	75.20	13.653	73.00
L8-M6	89.60	15.457	84.50	L8-M6	74.20	10.549	71.50
L9-M1	86.20	15.732	82.50	L9-M1	63.00	9.888	63.00
L9-M2	82.30	17.976	80.50	L9-M2	64.00	9.298	61.00
L9-M3	82.90	11.657	84.50	L9-M3	61.70	10.646	61.00
L9-M4	85.70	10.404	83.00	L9-M4	62.50	8.784	65.00

L9-M5	83.50	12.616	81.50	L9-M5	62.20	11.193	64.00
L9-M6	84.70	11.225	81.50	L9-M6	62.70	7.212	65.50
L10-M1	90.90	2.961	90.50	L10-M1	66.80	4.442	67.00
L10-M2	91.80	5.432	92.00	L10-M2	66.20	5.978	66.00
L10-M3	91.40	5.420	89.50	L10-M3	66.10	4.433	66.50
L10-M4	92.10	4.748	90.00	L10-M4	65.70	4.572	66.00
L10-M5	90.80	5.007	90.50	L10-M5	65.60	4.624	66.00
L10-M6	92.10	5.301	90.50	L10-M6	65.70	4.322	65.50

c. Mean, median and SD of closure duration (msec) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ka/	Benchmark	107.20	15.583	107.00	/ga/	Benchmark	72.20	13.105	75.00
	L1-M1	103.40	19.750	109.50		L1-M1	67.20	10.717	66.50
	L1-M2	91.90	23.163	85.50		L1-M2	64.80	16.123	68.00
	L1-M3	86.40	18.380	84.50		L1-M3	61.40	13.778	60.00
	L1-M4	82.10	21.952	80.50		L1-M4	58.40	9.252	57.50
	L1-M5	90.00	20.418	97.00		L1-M5	65.70	14.072	64.50
	L1-M6	94.60	18.963	95.50		L1-M6	65.60	11.088	63.50
	L2-M1	100.00	26.965	91.00		L2-M1	74.70	24.572	72.50
	L2-M2	109.20	34.509	105.50		L2-M2	72.90	27.863	66.00
	L2-M3	107.80	30.040	102.50		L2-M3	73.90	26.556	76.00
	L2-M4	106.80	29.907	102.50		L2-M4	71.70	21.334	72.50
	L2-M5	108.50	28.961	103.50		L2-M5	74.50	25.847	72.00
	L2-M6	107.00	28.829	98.00		L2-M6	73.80	23.794	70.00
	L3-M1	101.80	20.574	99.00		L3-M1	69.80	8.311	70.50
	L3-M2	100.00	16.492	96.50		L3-M2	61.10	24.182	63.50
	L3-M3	108.70	23.972	104.50		L3-M3	75.30	15.812	73.50
	L3-M4	103.70	28.375	97.50		L3-M4	77.00	17.095	71.50
	L3-M5	107.70	35.824	101.00		L3-M5	73.60	20.261	67.50

L3-M6	105.40	28.972	100.00	L3-M6	75.00	17.391	71.50
L4-M1	106.80	32.516	98.00	L4-M1	60.30	17.957	61.50
L4-M2	105.70	18.851	100.00	L4-M2	63.90	15.765	67.50
L4-M3	97.20	13.315	97.00	L4-M3	57.50	14.706	63.50
L4-M4	100.30	17.808	97.00	L4-M4	62.50	17.213	66.00
L4-M5	100.20	16.705	94.50	L4-M5	65.40	18.638	65.50
L4-M6	101.80	24.220	99.50	L4-M6	67.90	19.122	62.50
L5-M1	81.20	20.444	83.00	L5-M1	57.40	13.083	57.00
L5-M2	82.10	20.750	79.00	L5-M2	58.10	12.432	55.50
L5-M3	83.10	19.157	74.50	L5-M3	53.30	12.970	50.00
L5-M4	87.60	21.890	87.00	L5-M4	57.10	12.441	58.00
L5-M5	81.40	16.229	81.00	L5-M5	57.20	11.410	56.50
L5-M6	89.90	23.077	84.50	L5-M6	56.40	12.030	54.50
L6-M1	74.90	22.378	67.50	L6-M1	52.90	15.772	47.00
L6-M2	72.60	19.086	66.50	L6-M2	50.90	14.019	47.00
L6-M3	76.00	21.515	67.50	L6-M3	52.00	15.506	46.50
L6-M4	78.70	22.789	77.50	L6-M4	51.80	12.908	54.50
L6-M5	82.50	19.150	77.50	L6-M5	56.90	12.233	56.00
L6-M6	84.50	18.069	81.50	L6-M6	58.30	10.253	59.50
L7-M1	71.10	6.790	70.00	L7-M1	55.40	5.816	55.50
L7-M2	72.40	8.276	71.00	L7-M2	57.10	8.595	56.50
L7-M3	74.40	8.720	71.00	L7-M3	54.70	9.452	55.00
L7-M4	72.10	6.045	71.50	L7-M4	54.40	9.371	52.00
L7-M5	74.30	10.253	73.50	L7-M5	61.20	8.053	60.00
L7-M6	82.40	8.289	81.00	L7-M6	62.00	5.888	60.00
L8-M1	75.20	18.540	68.50	L8-M1	58.20	8.690	59.00
L8-M2	80.50	22.317	74.50	L8-M2	60.10	11.239	59.00
L8-M3	81.10	21.543	76.00	L8-M3	60.10	7.310	60.50
L8-M4	77.50	20.690	72.00	L8-M4	60.80	9.750	59.50
L8-M5	82.70	16.473	79.00	L8-M5	63.40	11.626	62.50

L8-M6	81.20	14.258	78.00	L8-M6	61.70	9.650	59.50
L9-M1	82.10	18.865	78.00	L9-M1	55.20	7.223	56.00
L9-M2	79.70	13.679	75.00	L9-M2	56.10	10.115	55.50
L9-M3	81.10	7.475	79.00	L9-M3	53.90	8.239	56.00
L9-M4	79.90	8.386	78.00	L9-M4	56.10	5.666	56.00
L9-M5	81.30	7.304	79.00	L9-M5	55.20	5.692	56.00
L9-M6	80.90	8.569	82.00	L9-M6	57.40	5.016	58.00
L10-M1	86.40	6.240	85.00	L10-M1	57.00	3.742	56.50
L10-M2	87.80	7.465	86.00	L10-M2	56.80	3.360	57.50
L10-M3	86.00	5.676	84.50	L10-M3	56.70	3.302	56.00
L10-M4	87.50	5.169	86.50	L10-M4	56.00	2.261	55.50
L10-M5	86.20	4.849	85.00	L10-M5	56.50	3.171	55.50
L10-M6	86.20	5.224	84.50	L10-M6	55.90	2.601	55.00

d. Mean, median and SD of closure duration (msec) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	116.00	16.391	112.00	/dha/	Benchmark	149.50	193.782	95.50
	L1-M1	107.80	35.736	96.50		L1-M1	90.70	12.544	89.50
	L1-M2	106.90	37.051	95.50		L1-M2	85.00	26.961	77.50
	L1-M3	99.60	22.564	92.50		L1-M3	77.50	19.812	71.50
	L1-M4	99.70	21.479	98.00		L1-M4	68.50	26.018	67.00
	L1-M5	94.20	23.598	92.50		L1-M5	71.20	20.563	69.50
	L1-M6	98.60	19.688	94.00		L1-M6	83.50	16.016	81.00
	L2-M1	118.00	32.992	100.00		L2-M1	79.80	23.122	78.50
	L2-M2	113.90	36.892	98.50		L2-M2	75.90	25.026	80.00
	L2-M3	116.60	32.851	112.00		L2-M3	79.90	23.009	87.00
	L2-M4	113.90	33.205	110.00		L2-M4	78.20	22.414	86.50
	L2-M5	115.50	32.535	123.00		L2-M5	79.70	26.663	84.00

L2-M6	116.20	37.252	111.00	L2-M6	78.20	21.760	74.00
L3-M1	98.50	23.969	94.00	L3-M1	80.30	13.728	76.00
L3-M2	105.40	29.945	94.50	L3-M2	67.40	25.352	72.50
L3-M3	100.40	18.277	97.00	L3-M3	78.80	14.823	78.50
L3-M4	104.40	28.403	94.00	L3-M4	73.90	10.049	71.00
L3-M5	101.70	35.248	89.00	L3-M5	81.20	22.963	71.50
L3-M6	101.00	28.640	95.00	L3-M6	79.30	18.270	71.50
L4-M1	109.40	28.305	101.00	L4-M1	71.50	18.722	71.50
L4-M2	113.60	26.471	110.50	L4-M2	77.80	20.308	83.00
L4-M3	105.60	26.341	100.50	L4-M3	71.50	19.104	73.50
L4-M4	105.20	24.760	104.00	L4-M4	76.80	19.043	74.00
L4-M5	109.90	27.311	107.00	L4-M5	76.60	20.764	74.00
L4-M6	103.80	21.612	95.00	L4-M6	77.40	19.126	75.50
L5-M1	88.80	19.865	83.00	L5-M1	67.50	9.324	64.50
L5-M2	87.80	22.651	83.50	L5-M2	70.10	8.825	68.00
L5-M3	92.60	23.282	84.50	L5-M3	67.90	11.522	66.00
L5-M4	94.50	21.235	84.50	L5-M4	66.60	8.720	66.50
L5-M5	87.30	23.367	81.00	L5-M5	68.10	13.178	65.50
L5-M6	88.90	19.649	80.50	L5-M6	68.90	7.767	68.50
L6-M1	84.00	26.566	79.00	L6-M1	66.20	16.625	70.50
L6-M2	81.60	22.307	72.50	L6-M2	68.10	14.647	65.00
L6-M3	82.70	27.645	74.50	L6-M3	66.40	19.080	64.00
L6-M4	85.80	28.886	75.50	L6-M4	71.20	20.552	68.50
L6-M5	87.40	19.608	81.50	L6-M5	74.80	18.305	69.00
L6-M6	84.40	21.067	79.00	L6-M6	71.40	15.328	69.00
L7-M1	75.50	9.536	74.50	L7-M1	64.80	5.266	63.50
L7-M2	78.20	10.861	77.00	L7-M2	68.30	4.523	68.00
L7-M3	80.90	6.136	80.50	L7-M3	67.40	3.373	67.00
L7-M4	77.20	5.692	76.50	L7-M4	66.40	4.971	65.50
L7-M5	76.90	8.373	78.50	L7-M5	72.90	5.216	73.00

L7-M6	81.90	5.705	81.50	L7-M6	72.80	10.497	74.00
L8-M1	115.50	33.294	96.50	L8-M1	73.20	6.828	71.00
L8-M2	114.70	34.448	101.50	L8-M2	73.10	9.539	70.00
L8-M3	115.70	28.585	112.00	L8-M3	73.90	7.923	74.50
L8-M4	113.20	31.340	110.00	L8-M4	75.10	14.533	74.50
L8-M5	114.30	28.511	123.00	L8-M5	75.90	8.800	75.00
L8-M6	111.30	37.556	111.00	L8-M6	75.80	11.312	73.00
L9-M1	85.40	12.483	82.50	L9-M1	69.80	8.108	68.00
L9-M2	88.80	12.044	88.00	L9-M2	69.40	7.975	68.50
L9-M3	86.60	11.711	84.50	L9-M3	70.60	6.501	69.50
L9-M4	88.50	8.554	88.50	L9-M4	72.10	7.866	74.50
L9-M5	90.00	8.260	88.50	L9-M5	69.90	9.362	71.50
L9-M6	88.80	9.004	88.00	L9-M6	70.60	9.021	72.00
L10-M1	87.90	1.729	88.00	L10-M1	73.00	3.496	73.50
L10-M2	90.10	2.079	90.00	L10-M2	73.30	4.057	73.50
L10-M3	91.10	4.433	91.00	L10-M3	71.90	2.644	73.00
L10-M4	90.20	3.645	89.50	L10-M4	73.30	3.093	73.50
L10-M5	88.90	4.254	87.50	L10-M5	72.90	3.071	73.50
L10-M6	89.60	3.239	88.00	L10-M6	72.80	3.645	74.00

Table 10

a. Mean, median and SD of transition duration (msec) for sounds /pa/ and /ba/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/pa/	Benchmark	22.80	2.821	24.00	/ba/	Benchmark	25.80	3.676	26.50
	L1-M1	22.80	8.311	24.00		L1-M1	25.00	2.789	25.00
	L1-M2	19.60	3.204	19.50		L1-M2	22.80	5.203	21.00
	L1-M3	19.60	2.836	19.00		L1-M3	21.60	2.413	21.00
	L1-M4	20.90	4.701	20.50		L1-M4	22.90	4.771	24.00

L1-M5	20.90	3.414	20.50	L1-M5	24.00	3.127	23.50
L1-M6	21.30	3.653	21.00	L1-M6	24.60	3.658	25.00
L2-M1	23.80	6.454	22.50	L2-M1	26.80	4.444	23.50
L2-M2	21.70	8.748	20.50	L2-M2	23.30	3.776	22.00
L2-M3	20.20	5.390	23.00	L2-M3	23.40	4.349	26.50
L2-M4	24.80	8.235	21.50	L2-M4	23.30	6.482	26.50
L2-M5	21.60	3.098	23.00	L2-M5	22.20	8.007	22.00
L2-M6	20.20	4.207	22.50	L2-M6	22.40	4.501	21.00
L3-M1	18.60	7.545	21.00	L3-M1	22.40	9.300	20.00
L3-M2	16.50	6.519	19.00	L3-M2	22.80	4.367	24.00
L3-M3	15.70	6.447	16.00	L3-M3	24.20	7.627	23.50
L3-M4	12.70	7.334	14.00	L3-M4	22.00	6.360	21.50
L3-M5	13.80	7.714	16.50	L3-M5	21.70	9.719	23.00
L3-M6	16.10	9.049	20.00	L3-M6	20.50	3.951	20.50
L4-M1	19.10	3.604	18.00	L4-M1	16.90	6.999	17.50
L4-M2	16.40	6.398	18.00	L4-M2	21.90	3.985	21.50
L4-M3	19.40	4.248	19.00	L4-M3	21.80	3.293	21.50
L4-M4	17.80	3.490	18.50	L4-M4	20.50	3.028	21.00
L4-M5	19.30	3.268	19.50	L4-M5	20.70	5.293	19.50
L4-M6	21.10	4.254	21.00	L4-M6	20.30	4.809	21.00
L5-M1	17.80	3.259	18.00	L5-M1	20.40	4.115	19.50
L5-M2	17.90	4.067	18.50	L5-M2	22.20	3.190	21.50
L5-M3	20.70	2.830	21.00	L5-M3	21.20	3.853	20.50
L5-M4	19.10	3.843	20.00	L5-M4	21.20	4.131	20.00
L5-M5	18.40	2.319	18.00	L5-M5	22.80	3.259	23.50
L5-M6	20.10	2.601	21.00	L5-M6	23.80	2.616	23.50
L6-M1	20.20	2.860	21.00	L6-M1	22.50	4.378	23.00
L6-M2	19.60	3.534	20.00	L6-M2	23.20	4.185	23.00
L6-M3	23.40	4.402	23.50	L6-M3	24.90	3.446	24.00
L6-M4	21.90	3.604	23.00	L6-M4	24.40	5.125	24.00

L6-M5	20.60	3.406	20.00	L6-M5	23.20	4.662	22.00
L6-M6	21.40	3.950	22.00	L6-M6	22.70	2.830	22.00
L7-M1	21.00	5.850	23.00	L7-M1	24.70	6.111	22.50
L7-M2	20.60	10.047	25.50	L7-M2	21.40	9.058	22.00
L7-M3	23.50	8.528	27.50	L7-M3	25.60	7.734	26.00
L7-M4	23.60	7.947	24.50	L7-M4	26.40	7.961	28.00
L7-M5	25.70	9.154	24.00	L7-M5	25.50	8.100	27.00
L7-M6	24.60	12.456	30.50	L7-M6	27.10	6.935	26.50
L8-M1	22.10	3.900	22.50	L8-M1	21.10	8.913	22.00
L8-M2	35.20	35.418	27.00	L8-M2	25.40	11.286	25.50
L8-M3	22.60	10.330	26.00	L8-M3	23.60	10.532	25.00
L8-M4	23.50	10.168	25.50	L8-M4	27.00	6.164	26.00
L8-M5	23.80	9.942	25.50	L8-M5	25.20	2.936	25.50
L8-M6	24.00	10.435	27.00	L8-M6	25.30	11.275	26.00
L9-M1	23.90	5.685	22.00	L9-M1	23.20	2.821	22.00
L9-M2	22.30	4.218	23.50	L9-M2	22.30	5.397	23.00
L9-M3	22.30	2.908	23.00	L9-M3	26.00	3.590	27.00
L9-M4	21.50	3.171	22.50	L9-M4	25.60	4.551	26.00
L9-M5	22.80	2.658	22.50	L9-M5	27.80	6.861	26.50
L9-M6	20.80	2.201	20.50	L9-M6	25.20	3.853	24.00
L10-M1	20.60	3.373	21.50	L10-M1	24.30	2.908	24.50
L10-M2	23.50	3.408	23.00	L10-M2	25.00	4.163	25.00
L10-M3	23.50	1.958	23.50	L10-M3	26.40	4.061	25.50
L10-M4	24.70	2.710	25.00	L10-M4	25.80	4.756	24.00
L10-M5	24.40	3.239	23.50	L10-M5	25.00	6.880	24.50
L10-M6	25.10	3.071	26.00	L10-M6	23.00	3.830	22.50

b. Mean, median and SD of transition duration (msec) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median

/ta/	Benchmark	25.10	1.853	25.50	/da/	Benchmark	28.40	4.326	29.00
	L1-M1	22.90	3.446	22.50		L1-M1	26.90	4.383	29.00
	L1-M2	21.90	3.071	22.50		L1-M2	27.80	4.517	27.50
	L1-M3	20.60	3.777	20.50		L1-M3	25.20	9.531	26.00
	L1-M4	21.70	2.111	21.00		L1-M4	25.80	3.011	25.50
	L1-M5	22.80	2.300	23.00		L1-M5	26.80	3.584	27.00
	L1-M6	22.70	3.561	23.00		L1-M6	26.10	2.807	26.50
	L2-M1	22.90	3.503	25.00		L2-M1	21.70	4.615	20.50
	L2-M2	21.90	5.503	21.50		L2-M2	22.00	3.138	22.00
	L2-M3	22.50	6.313	21.50		L2-M3	22.80	4.182	25.00
	L2-M4	21.40	3.834	23.00		L2-M4	21.10	3.638	20.00
	L2-M5	21.90	5.855	22.00		L2-M5	21.50	6.549	24.50
	L2-M6	23.00	4.926	20.00		L2-M6	22.00	8.441	22.00
	L3-M1	21.80	2.700	23.00		L3-M1	21.70	4.809	22.50
	L3-M2	20.70	4.270	21.50		L3-M2	23.00	6.164	23.00
	L3-M3	18.60	3.950	18.50		L3-M3	21.40	6.637	21.00
	L3-M4	16.00	7.542	17.50		L3-M4	22.30	3.889	21.50
	L3-M5	19.40	4.006	20.00		L3-M5	20.30	7.973	21.50
	L3-M6	15.70	8.499	18.50		L3-M6	24.90	4.175	25.00
	L4-M1	21.70	2.791	21.50		L4-M1	23.60	4.033	22.50
	L4-M2	21.70	2.406	21.50		L4-M2	23.20	3.938	21.50
	L4-M3	19.50	3.342	19.50		L4-M3	23.90	5.021	23.00
	L4-M4	21.40	3.836	20.00		L4-M4	24.20	4.780	23.50
	L4-M5	21.60	4.351	21.00		L4-M5	21.70	3.917	21.50
	L4-M6	21.50	2.953	22.00		L4-M6	24.70	4.191	23.50
	L5-M1	19.20	3.615	20.00		L5-M1	22.80	3.882	22.00
	L5-M2	18.70	4.448	18.50		L5-M2	23.90	3.843	23.50
	L5-M3	21.70	3.529	22.00		L5-M3	23.40	3.596	23.50
	L5-M4	20.90	3.281	20.50		L5-M4	21.70	2.751	22.50
	L5-M5	20.30	3.889	20.50		L5-M5	23.90	4.280	23.50

L5-M6	22.30	3.773	23.00	L5-M6	25.00	3.232	25.50
L6-M1	22.20	2.044	22.00	L6-M1	22.50	2.953	22.50
L6-M2	19.40	3.273	19.50	L6-M2	22.90	3.479	24.00
L6-M3	22.10	3.872	22.50	L6-M3	23.10	4.012	24.00
L6-M4	22.50	5.662	23.50	L6-M4	23.40	4.274	24.00
L6-M5	24.00	6.377	23.50	L6-M5	21.30	3.683	21.00
L6-M6	20.80	5.160	22.50	L6-M6	21.90	3.872	23.50
L7-M1	18.90	4.122	17.00	L7-M1	21.00	3.266	22.00
L7-M2	20.30	9.684	24.00	L7-M2	19.50	8.045	21.50
L7-M3	23.30	4.547	23.00	L7-M3	21.10	3.872	22.50
L7-M4	23.80	6.125	23.50	L7-M4	21.70	5.143	22.00
L7-M5	24.50	5.039	24.00	L7-M5	21.10	4.280	21.00
L7-M6	25.80	6.630	25.50	L7-M6	20.60	4.274	21.50
L8-M1	23.10	5.953	22.50	L8-M1	21.10	7.838	22.50
L8-M2	22.60	9.991	25.00	L8-M2	21.00	7.760	23.00
L8-M3	23.50	9.902	25.50	L8-M3	21.50	8.100	24.00
L8-M4	23.60	10.047	23.50	L8-M4	20.00	7.394	21.50
L8-M5	24.20	10.549	24.50	L8-M5	20.80	7.685	23.00
L8-M6	23.50	11.674	26.50	L8-M6	20.30	8.097	22.50
L9-M1	23.80	4.050	23.50	L9-M1	23.90	5.567	23.00
L9-M2	23.70	5.458	22.00	L9-M2	23.80	4.185	24.00
L9-M3	24.70	4.668	23.50	L9-M3	23.90	3.604	24.00
L9-M4	25.00	5.696	22.50	L9-M4	25.30	4.218	26.50
L9-M5	22.50	1.780	22.00	L9-M5	25.80	4.566	27.50
L9-M6	25.30	2.584	24.50	L9-M6	23.80	4.392	23.50
L10-M1	23.90	4.040	22.00	L10-M1	24.40	3.169	25.50
L10-M2	25.10	2.601	24.00	L10-M2	27.90	3.872	29.00
L10-M3	25.70	4.322	26.00	L10-M3	25.50	3.206	26.50
L10-M4	26.60	4.427	24.50	L10-M4	24.90	2.961	25.50
L10-M5	26.60	2.757	26.50	L10-M5	26.20	2.348	26.50

L10-M6	25.00	2.357	25.50	L10-M6	26.20	2.781	26.50

c. Mean, median and SD of transition duration (msec) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ka/	Benchmark	26.33	2.550	26.00	/ga/	Benchmark	33.20	3.706	34.50
	L1-M1	21.22	9.011	22.00		L1-M1	30.10	7.031	30.00
	L1-M2	22.33	3.391	23.00		L1-M2	30.20	5.770	29.50
	L1-M3	22.89	3.855	21.00		L1-M3	29.40	4.624	29.00
	L1-M4	24.67	4.387	24.00		L1-M4	27.70	4.165	29.00
	L1-M5	25.00	3.082	25.00		L1-M5	28.20	4.392	28.50
	L1-M6	24.78	3.528	25.00		L1-M6	28.20	3.327	29.00
	L2-M1	24.22	3.099	22.00		L2-M1	23.70	4.000	24.00
	L2-M2	21.67	7.281	22.00		L2-M2	23.90	5.845	22.00
	L2-M3	23.67	4.800	22.00		L2-M3	24.10	6.767	22.00
	L2-M4	25.00	3.052	23.00		L2-M4	23.00	4.785	20.50
	L2-M5	26.22	6.607	21.00		L2-M5	24.00	6.338	23.50
	L2-M6	24.11	8.263	24.00		L2-M6	24.00	3.816	22.00
	L3-M1	22.22	6.160	21.00		L3-M1	25.80	8.404	23.00
	L3-M2	20.78	8.913	23.00		L3-M2	23.80	6.443	21.50
	L3-M3	22.33	10.404	26.00		L3-M3	23.70	5.559	24.00
	L3-M4	25.56	7.161	21.00		L3-M4	21.60	6.569	21.00
	L3-M5	22.67	10.689	22.00		L3-M5	21.40	9.119	23.00
	L3-M6	20.33	5.916	21.00		L3-M6	26.90	3.784	27.00
	L4-M1	24.22	4.684	22.00		L4-M1	26.00	4.137	24.00
	L4-M2	23.56	2.789	23.00		L4-M2	24.30	3.889	23.50
	L4-M3	24.00	4.359	24.00		L4-M3	26.60	5.190	28.00
	L4-M4	24.44	2.455	24.00		L4-M4	24.80	4.417	24.00
	L4-M5	24.44	4.558	24.00		L4-M5	25.20	2.974	25.50
	L4-M6	23.56	3.909	25.00		L4-M6	26.30	2.214	26.50

L5-M1	19.33	4.975	19.00	L5-M1	24.40	4.624	25.00
L5-M2	23.33	3.708	23.00	L5-M2	25.30	3.199	26.00
L5-M3	23.22	4.816	20.00	L5-M3	27.20	4.709	28.50
L5-M4	21.44	3.812	23.00	L5-M4	23.90	4.332	23.00
L5-M5	21.00	3.536	23.00	L5-M5	23.70	4.322	22.50
L5-M6	23.78	3.346	24.00	L5-M6	27.10	3.348	26.50
L6-M1	21.67	3.937	22.00	L6-M1	26.80	4.686	25.00
L6-M2	23.00	3.240	23.00	L6-M2	25.80	3.259	26.00
L6-M3	23.67	3.775	25.00	L6-M3	22.90	5.087	23.00
L6-M4	24.00	5.025	26.00	L6-M4	25.50	4.116	23.50
L6-M5	23.11	2.261	23.00	L6-M5	25.30	3.057	25.00
L6-M6	23.44	2.404	24.00	L6-M6	24.30	2.584	24.00
L7-M1	22.67	3.571	23.00	L7-M1	23.60	6.004	24.00
L7-M2	17.89	7.288	19.00	L7-M2	21.70	8.287	23.00
L7-M3	20.78	6.119	20.00	L7-M3	23.70	4.900	24.50
L7-M4	24.11	5.302	23.00	L7-M4	24.90	3.784	24.00
L7-M5	25.89	6.030	25.00	L7-M5	24.60	2.066	24.00
L7-M6	23.89	10.130	25.00	L7-M6	25.40	3.502	25.00
L8-M1	24.78	3.232	25.00	L8-M1	23.30	9.007	26.00
L8-M2	24.33	9.631	28.00	L8-M2	19.30	10.636	23.00
L8-M3	23.22	10.353	24.00	L8-M3	23.00	8.819	24.00
L8-M4	26.78	7.839	26.00	L8-M4	25.40	3.627	24.50
L8-M5	26.67	7.280	23.00	L8-M5	25.50	3.689	24.50
L8-M6	24.44	11.609	28.00	L8-M6	22.90	8.293	25.50
L9-M1	24.33	3.317	25.00	L9-M1	24.00	5.657	23.00
L9-M2	27.00	2.449	28.00	L9-M2	25.20	5.029	24.50
L9-M3	25.78	4.658	25.00	L9-M3	28.60	8.289	28.50
L9-M4	25.89	2.667	26.00	L9-M4	28.90	9.267	25.00
L9-M5	25.78	4.353	25.00	L9-M5	29.10	4.458	29.50
L9-M6	24.89	2.848	24.00	L9-M6	28.00	5.558	26.50

	L10-M1	22.33	1.803	22.00		L10-M1	29.30	6.147	31.00
	L10-M2	25.89	3.180	26.00		L10-M2	30.10	5.301	31.00
	L10-M3	24.00	1.871	24.00		L10-M3	28.50	6.754	25.50
	L10-M4	27.33	3.937	27.00		L10-M4	28.90	5.109	27.50
	L10-M5	27.56	3.127	28.00		L10-M5	26.90	4.954	24.50
	L10-M6	25.67	2.739	25.00		L10-M6	28.50	6.060	30.00

d. Mean, median and SD of transition duration (msec) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	25.40	3.688	25.00	/dha/	Benchmark	29.80	3.360	29.50
	L1-M1	23.80	3.120	24.50		L1-M1	23.00	8.300	26.00
	L1-M2	22.00	3.333	22.50		L1-M2	27.10	4.332	26.50
	L1-M3	21.70	2.627	21.50		L1-M3	25.90	3.143	25.50
	L1-M4	24.60	4.274	24.50		L1-M4	25.80	4.315	24.50
	L1-M5	22.70	4.644	22.00		L1-M5	25.30	4.347	25.00
	L1-M6	24.60	4.551	23.50		L1-M6	26.80	4.733	26.00
	L2-M1	19.80	6.315	19.00		L2-M1	23.70	7.698	21.50
	L2-M2	21.80	4.877	22.50		L2-M2	23.80	5.439	22.00
	L2-M3	22.10	8.503	22.00		L2-M3	24.00	3.175	20.50
	L2-M4	21.90	5.348	22.50		L2-M4	25.20	6.902	24.00
	L2-M5	21.70	3.363	22.00		L2-M5	26.80	8.896	25.50
	L2-M6	21.30	6.573	23.50		L2-M6	26.30	3.490	21.50
	L3-M1	18.40	4.142	17.50		L3-M1	23.80	6.015	22.00
	L3-M2	19.10	4.175	18.00		L3-M2	22.70	3.713	23.50
	L3-M3	18.50	7.337	21.00		L3-M3	23.60	6.467	22.00
	L3-M4	17.90	8.006	19.00		L3-M4	22.00	8.287	21.50
	L3-M5	17.80	7.554	18.50		L3-M5	18.20	8.535	19.00
	L3-M6	23.50	2.550	23.00		L3-M6	24.10	3.635	23.50

L4-M1	20.90	2.234	21.00	L4-M1	20.30	8.642	22.00
L4-M2	19.00	3.232	19.50	L4-M2	21.50	5.276	21.00
L4-M3	21.00	4.899	21.00	L4-M3	22.70	4.218	21.50
L4-M4	21.00	5.164	19.50	L4--M4	24.60	2.914	23.50
L4-M5	21.90	2.961	21.00	L4-M5	22.20	4.541	22.00
L4-M6	23.60	3.627	23.00	L4-M6	24.20	3.967	24.00
L5-M1	21.60	3.307	20.50	L5-M1	24.30	4.832	24.00
L5-M2	21.60	4.551	21.00	L5-M2	25.00	3.091	24.50
L5-M3	21.30	4.596	20.50	L5-M3	22.80	3.393	22.50
L5-M4	22.50	3.375	22.50	L5-M4	24.00	2.309	23.50
L5-M5	23.40	3.406	23.50	L5-M5	25.80	4.077	26.00
L5-M6	23.80	3.225	22.50	L5-M6	25.40	2.066	25.00
L6-M1	24.10	3.542	24.50	L6-M1	25.30	3.683	24.00
L6-M2	21.90	3.414	23.50	L6-M2	26.10	4.557	27.50
L6-M3	23.70	4.296	23.50	L6-M3	25.00	3.399	24.00
L6-M4	24.90	4.508	25.00	L6-M4	27.40	5.211	26.50
L6-M5	21.80	3.645	23.00	L6-M5	25.60	5.082	23.00
L6-M6	23.70	3.401	23.00	L6-M6	25.20	4.442	26.50
L7-M1	23.20	3.190	23.00	L7-M1	24.50	5.583	22.00
L7-M2	22.70	8.407	25.00	L7-M2	23.10	8.787	26.00
L7-M3	23.10	3.542	23.00	L7-M3	25.40	7.168	24.50
L7-M4	23.30	4.111	23.00	L7-M4	28.30	4.968	27.00
L7-M5	24.10	2.767	24.50	L7-M5	25.30	5.697	24.50
L7-M6	23.90	2.961	24.00	L7-M6	24.00	9.661	26.50
L8-M1	23.00	4.137	23.50	L8-M1	20.80	7.969	22.00
L8-M2	20.20	10.850	24.00	L8-M2	22.20	8.176	25.00
L8-M3	20.00	7.542	21.00	L8-M3	21.30	8.693	23.50
L8-M4	23.30	8.769	25.50	L8-M4	25.10	3.213	25.00
L8-M5	21.20	7.997	23.00	L8-M5	24.40	3.777	24.00
L8-M6	23.10	8.346	25.50	L8-M6	23.30	8.433	26.50

L9-M1	24.00	2.708	22.50	L9-M1	25.60	3.806	25.00
L9-M2	26.20	3.048	26.00	L9-M2	27.00	6.600	26.50
L9-M3	23.50	5.233	23.00	L9-M3	28.10	5.021	28.50
L9-M4	25.00	6.342	23.50	L9-M4	26.60	4.402	26.00
L9-M5	25.90	3.665	25.50	L9-M5	28.50	5.603	30.00
L9-M6	24.70	2.830	23.50	L9-M6	24.30	5.143	23.00
L10-M1	25.10	4.358	23.50	L10-M1	24.70	3.773	25.00
L10-M2	24.80	3.584	24.50	L10-M2	27.30	3.917	27.00
L10-M3	25.20	4.894	24.50	L10-M3	25.70	2.830	26.00
L10-M4	23.30	4.423	23.50	L10-M4	24.00	5.907	23.50
L10-M5	27.40	2.716	27.00	L10-M5	24.50	2.461	25.00
L10-M6	25.80	4.614	24.00	L10-M6	25.60	2.914	25.50

Table 11

a. Mean, median and SD of spectral tilt (dB/Hz) for sounds /pa/ and /ba/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/pa/	Benchmark	13.00	1.826	13.50	/ba/	Benchmark	16.40	1.350	17.00
	L1-M1	22.80	4.467	23.00		L1-M1	25.40	7.321	23.50
	L1-M2	22.30	6.430	24.50		L1-M2	26.70	5.889	27.00
	L1-M3	21.10	4.095	23.00		L1-M3	26.80	4.826	26.50
	L1-M4	22.50	4.927	24.00		L1-M4	25.10	2.726	25.00
	L1-M5	23.40	4.742	25.00		L1-M5	25.60	4.812	26.00
	L1-M6	22.20	4.803	23.50		L1-M6	23.80	2.300	23.50
	L2-M1	34.60	10.752	34.50		L2-M1	43.00	5.185	44.50
	L2-M2	36.80	6.161	36.00		L2-M2	42.10	4.202	43.50
	L2-M3	32.70	5.355	34.50		L2-M3	39.00	6.464	40.00
	L2-M4	37.30	6.360	36.50		L2-M4	41.50	4.972	43.50
	L2-M5	37.20	7.036	38.00		L2-M5	41.90	5.363	42.50

L2-M6	38.10	7.156	39.00	L2-M6	42.70	4.347	44.50
L3-M1	29.80	4.614	30.50	L3-M1	38.10	4.999	35.50
L3-M2	29.60	5.948	29.50	L3-M2	36.00	5.944	34.50
L3-M3	29.30	4.138	29.50	L3-M3	33.10	6.262	33.00
L3-M4	28.10	5.152	27.00	L3-M4	35.30	4.968	35.00
L3-M5	32.70	4.523	31.50	L3-M5	35.00	2.309	34.50
L3-M6	28.20	4.185	27.50	L3-M6	34.20	6.250	34.00
L4-M1	25.20	4.614	25.00	L4-M1	27.60	3.502	26.00
L4-M2	26.40	6.518	26.50	L4-M2	26.30	4.762	27.50
L4-M3	23.70	5.376	23.00	L4-M3	24.50	4.249	24.50
L4-M4	26.10	6.935	26.00	L4-M4	28.10	4.149	28.00
L4-M5	24.40	7.074	24.50	L4-M5	27.20	2.936	27.00
L4-M6	25.20	8.351	26.00	L4-M6	27.40	4.195	27.50
L5-M1	23.60	5.168	23.00	L5-M1	27.00	3.399	26.00
L5-M2	23.00	6.325	25.50	L5-M2	26.10	2.079	26.50
L5-M3	24.70	5.293	23.00	L5-M3	27.20	4.315	27.50
L5-M4	28.10	6.488	29.00	L5-M4	27.60	4.904	28.50
L5-M5	24.00	5.578	23.00	L5-M5	27.50	2.877	27.50
L5-M6	25.90	3.872	26.50	L5-M6	26.70	3.683	27.50
L6-M1	25.60	4.526	24.50	L6-M1	25.80	3.910	25.00
L6-M2	25.20	2.348	25.00	L6-M2	26.80	2.573	26.50
L6-M3	25.40	2.875	25.00	L6-M3	26.50	2.877	27.00
L6-M4	26.00	4.738	25.00	L6-M4	27.80	5.391	27.50
L6-M5	27.10	5.626	27.00	L6-M5	27.60	5.816	26.00
L6-M6	27.70	4.165	28.00	L6-M6	26.20	4.917	27.00
L7-M1	23.70	6.993	22.50	L7-M1	24.60	3.340	25.50
L7-M2	22.70	7.528	24.00	L7-M2	25.50	5.191	27.00
L7-M3	27.10	5.624	27.00	L7-M3	22.80	6.106	25.50
L7-M4	21.50	5.836	23.00	L7-M4	24.40	5.400	26.50
L7-M5	23.70	5.794	24.50	L7-M5	27.40	4.452	27.00

	L7-M6	24.20	3.824	23.00		L7-M6	23.80	4.492	24.00
	L8-M1	21.50	5.821	23.80		L8-M1	30.50	4.673	33.50
	L8-M2	20.70	6.430	23.00		L8-M2	35.00	3.859	37.00
	L8-M3	23.30	6.601	24.50		L8-M3	34.00	5.907	35.50
	L8-M4	25.40	4.881	26.00		L8-M4	30.60	5.621	30.50
	L8-M5	22.40	6.310	23.00		L8-M5	33.60	5.379	36.50
	L8-M6	24.20	5.493	24.50		L8-M6	28.30	4.644	28.50
	L9-M1	29.10	6.935	31.00		L9-M1	23.30	2.312	24.00
	L9-M2	27.70	7.528	27.00		L9-M2	23.40	5.835	23.50
	L9-M3	24.90	7.622	24.50		L9-M3	25.20	3.584	26.00
	L9-M4	30.00	9.649	27.50		L9-M4	25.40	3.406	26.00
	L9-M5	26.50	5.148	24.00		L9-M5	25.30	2.111	25.50
	L9-M6	31.70	7.196	30.00		L9-M6	23.10	4.581	23.50
	L10-M1	26.50	4.950	27.50		L10-M1	24.70	4.111	25.50
	L10-M2	26.40	3.836	26.00		L10-M2	25.90	3.178	27.00
	L10-M3	25.30	3.889	24.00		L10-M3	26.70	1.767	27.00
	L10-M4	27.00	7.333	27.50		L10-M4	25.30	2.908	26.00
	L10-M5	26.00	7.717	26.00		L10-M5	24.30	3.433	24.50
	L10-M6	25.50	7.792	23.00		L10-M6	27.00	2.494	26.50

b. Mean, median and SD of spectral tilt (dB/Hz) for sounds /ta/ and /da/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/ta/	Benchmark	14.50	2.068	14.50	/da/	Benchmark	20.20	1.989	20.50
	L1-M1	21.60	8.514	21.00		L1-M1	28.50	9.372	29.00
	L1-M2	23.20	6.713	24.50		L1-M2	29.30	5.272	28.00
	L1-M3	24.40	5.758	27.00		L1-M3	27.70	6.378	26.00
	L1-M4	23.10	1.853	23.00		L1-M4	28.60	6.535	28.00
	L1-M5	21.80	4.341	22.00		L1-M5	29.70	4.715	28.00

L1-M6	23.30	3.773	22.50	L1-M6	28.80	4.022	28.00
L2-M1	36.80	7.300	37.00	L2-M1	30.40	10.501	28.50
L2-M2	37.30	6.881	38.00	L2-M2	30.60	7.633	28.50
L2-M3	34.90	4.864	36.50	L2-M3	29.70	6.237	30.50
L2-M4	39.60	6.222	39.50	L2-M4	31.20	5.453	32.00
L2-M5	37.70	5.908	36.00	L2-M5	31.80	6.339	32.00
L2-M6	38.30	6.767	40.50	L2-M6	30.00	8.083	29.50
L3-M1	29.00	9.055	31.50	L3-M1	27.10	6.402	24.50
L3-M2	30.80	6.828	31.50	L3-M2	28.10	7.564	26.50
L3-M3	28.90	3.900	28.00	L3-M3	30.40	6.501	27.50
L3-M4	29.60	6.687	28.00	L3-M4	32.70	8.381	32.00
L3-M5	29.80	5.712	30.00	L3-M5	29.70	5.716	27.50
L3-M6	28.60	4.088	28.00	L3-M6	31.30	7.196	29.00
L4-M1	25.10	3.725	24.00	L4-M1	26.90	3.872	27.00
L4-M2	25.90	4.332	25.00	L4-M2	24.10	5.109	23.00
L4-M3	23.10	2.283	23.00	L4-M3	23.70	4.715	23.50
L4-M4	23.80	3.584	22.50	L4-M4	29.40	6.450	28.00
L4-M5	25.10	2.807	25.50	L4-M5	26.90	6.297	24.50
L4-M6	24.30	3.020	23.50	L4-M6	25.80	4.442	24.50
L5-M1	26.80	4.756	26.00	L5-M1	33.60	6.150	34.00
L5-M2	29.10	7.062	30.00	L5-M2	30.50	5.543	33.50
L5-M3	26.80	4.638	25.00	L5-M3	32.80	3.938	34.50
L5-M4	28.80	4.541	27.00	L5-M4	32.20	8.867	33.50
L5-M5	27.10	6.385	27.50	L5-M5	33.00	4.690	35.00
L5-M6	25.00	3.091	25.00	L5-M6	34.70	3.498	33.00
L6-M1	27.00	2.160	27.00	L6-M1	33.80	7.598	35.00
L6-M2	26.60	3.978	25.00	L6-M2	28.60	4.452	31.00
L6-M3	26.70	3.561	27.50	L6-M3	30.40	4.835	30.00
L6-M4	24.70	4.244	24.50	L6-M4	28.30	8.564	27.50
L6-M5	24.90	3.035	25.00	L6-M5	30.60	6.004	29.50

	L6-M6	23.90	3.178	25.00		L6-M6	31.70	7.394	30.00
	L7-M1	23.80	4.566	25.00		L7-M1	29.40	5.296	29.50
	L7-M2	22.80	3.155	23.00		L7-M2	29.50	7.502	29.00
	L7-M3	23.00	3.300	22.00		L7-M3	31.70	7.718	33.00
	L7-M4	23.90	4.954	24.00		L7-M4	28.00	5.637	26.00
	L7-M5	23.20	2.251	22.50		L7-M5	28.40	5.835	27.00
	L7-M6	24.20	2.741	24.00		L7-M6	31.30	5.638	32.50
	L8-M1	23.10	3.035	24.00		L8-M1	26.50	5.720	25.50
	L8-M2	24.90	4.202	23.50		L8-M2	32.30	5.438	32.00
	L8-M3	23.80	3.553	23.00		L8-M3	28.30	5.417	28.00
	L8-M4	24.20	3.882	25.00		L8-M4	27.40	3.950	25.50
	L8-M5	23.70	3.368	24.00		L8-M5	27.40	4.766	28.50
	L8-M6	24.20	2.700	24.50		L8-M6	27.90	5.195	26.00
	L9-M1	23.00	2.867	23.00		L9-M1	33.80	4.614	35.00
	L9-M2	23.60	3.893	23.50		L9-M2	33.90	5.859	32.50
	L9-M3	24.60	4.088	24.50		L9-M3	34.80	7.815	33.50
	L9-M4	24.10	3.900	24.50		L9-M4	36.40	6.433	36.50
	L9-M5	24.20	3.190	24.50		L9-M5	36.00	7.916	36.50
	L9-M6	24.60	2.459	25.00		L9-M6	37.50	4.428	37.50
	L10-M1	27.40	7.442	26.00		L10-M1	30.20	7.642	29.00
	L10-M2	28.70	5.618	26.00		L10-M2	32.10	7.490	32.00
	L10-M3	28.50	4.249	27.50		L10-M3	32.00	8.014	32.00
	L10-M4	32.70	8.125	34.00		L10-M4	33.50	7.352	35.00
	L10-M5	34.20	8.244	34.50		L10-M5	30.90	9.597	29.00
	L10-M6	26.00	4.346	25.50		L10-M6	27.90	7.156	26.00

c. Mean, median and SD of spectral tilt (dB/Hz) for sounds /ka/ and /ga/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median

/ka/	Benchmark	16.00	2.708	16.50	/ga/	Benchmark	17.70	1.418	18.00
	L1-M1	23.20	7.227	23.50		L1-M1	28.20	8.189	31.50
	L1-M2	23.50	5.523	25.00		L1-M2	24.10	3.900	25.00
	L1-M3	25.10	4.748	25.50		L1-M3	26.00	4.761	24.00
	L1-M4	23.30	5.143	24.00		L1-M4	28.40	7.919	24.50
	L1-M5	23.00	4.546	23.50		L1-M5	26.10	5.322	26.00
	L1-M6	23.20	3.155	24.00		L1-M6	25.60	3.777	25.00
	L2-M1	34.10	10.24	36.50		L2-M1	35.50	6.786	34.50
	L2-M2	36.70	7.761	37.50		L2-M2	39.00	6.018	40.00
	L2-M3	37.90	6.967	38.50		L2-M3	37.80	6.303	39.00
	L2-M4	39.30	4.692	39.00		L2-M4	35.50	7.106	36.00
	L2-M5	36.50	6.096	36.50		L2-M5	41.10	5.384	41.00
	L2-M6	36.10	5.466	36.00		L2-M6	41.20	6.033	42.50
	L3-M1	29.70	4.968	30.50		L3-M1	28.00	3.859	26.50
	L3-M2	29.90	5.446	32.50		L3-M2	30.00	6.600	31.00
	L3-M3	29.40	4.926	29.50		L3-M3	28.70	4.001	29.50
	L3-M4	28.50	3.808	28.00		L3-M4	28.40	5.400	27.00
	L3-M5	31.60	7.545	29.50		L3-M5	30.20	8.176	28.00
	L3-M6	28.60	6.720	26.00		L3-M6	29.30	4.990	29.00
	L4-M1	32.60	8.113	33.00		L4-M1	25.90	2.923	25.00
	L4-M2	33.50	5.968	33.50		L4-M2	26.70	7.243	23.00
	L4-M3	29.20	4.733	26.50		L4-M3	29.30	7.072	28.00
	L4-M4	28.10	6.471	28.50		L4-M4	27.20	5.922	26.50
	L4-M5	31.70	5.926	30.00		L4-M5	29.20	4.894	29.00
	L4-M6	28.80	7.300	29.50		L4-M6	28.70	3.860	28.50
	L5-M1	32.20	7.330	29.50		L5-M1	36.30	3.743	35.50
	L5-M2	29.60	6.381	29.50		L5-M2	32.80	5.051	33.50
	L5-M3	30.80	5.712	29.00		L5-M3	32.00	3.801	33.00
	L5-M4	30.20	4.662	33.00		L5-M4	33.10	4.095	34.00
	L5-M5	32.40	5.082	34.00		L5-M5	36.30	3.860	35.00

L5-M6	33.10	7.094	33.00	L5-M6	35.80	4.077	35.50
L6-M1	26.60	3.978	25.50	L6-M1	31.70	5.559	32.00
L6-M2	27.00	4.320	26.50	L6-M2	32.50	5.662	34.00
L6-M3	28.80	4.590	28.50	L6-M3	30.60	5.522	30.50
L6-M4	31.40	4.195	33.00	L6-M4	29.60	4.742	31.00
L6-M5	29.30	4.596	30.00	L6-M5	31.20	3.553	32.00
L6-M6	28.90	6.385	27.50	L6-M6	30.90	7.031	32.50
L7-M1	32.90	8.925	33.50	L7-M1	29.00	4.522	27.50
L7-M2	34.20	7.021	35.50	L7-M2	27.40	7.706	24.00
L7-M3	33.10	8.478	33.00	L7-M3	26.50	4.950	26.00
L7-M4	34.70	5.870	36.50	L7-M4	28.70	4.620	27.50
L7-M5	35.50	5.911	35.50	L7-M5	25.80	4.962	23.50
L7-M6	40.10	6.540	43.50	L7-M6	26.10	2.601	26.50
L8-M1	28.10	5.021	26.00	L8-M1	24.90	3.281	24.00
L8-M2	30.10	4.932	30.00	L8-M2	28.90	7.709	28.00
L8-M3	27.80	6.730	25.00	L8-M3	24.00	8.233	25.50
L8-M4	30.00	6.200	28.50	L8-M4	27.20	4.566	26.00
L8-M5	29.70	8.551	26.00	L8-M5	25.70	4.877	26.50
L8-M6	29.30	5.034	28.00	L8-M6	25.90	3.143	26.00
L9-M1	27.10	6.154	25.50	L9-M1	23.90	1.853	24.00
L9-M2	28.90	7.520	27.00	L9-M2	27.30	7.469	24.50
L9-M3	26.60	3.777	27.00	L9-M3	22.90	8.900	25.50
L9-M4	28.90	7.866	26.50	L9-M4	24.10	3.348	24.50
L9-M5	29.70	7.088	27.50	L9-M5	25.10	4.358	25.50
L9-M6	31.30	7.689	28.50	L9-M6	25.60	4.195	23.50
L10-M1	30.60	6.222	33.50	L10-M1	27.40	4.742	26.00
L10-M2	27.20	7.714	29.50	L10-M2	26.50	5.233	26.00
L10-M3	26.70	9.911	28.00	L10-M3	25.80	2.530	25.50
L10-M4	28.00	10.17	27.50	L10-M4	27.70	5.293	26.50
L10-M5	27.60	8.409	25.50	L10-M5	26.90	3.985	27.00

L10-M6	31.00	6.782	31.50		L10-M6	27.40	4.551	26.00

d. Mean, median and SD of spectral tilt (dB/Hz) for sounds /tha/ and /dha/ for different recording combinations

Sound	Combination	Mean	SD	Median	Sound	Combination	Mean	SD	Median
/tha/	Benchmark	16.90	1.287	17.00	/dha/	Benchmark	20.20	1.033	20.00
	L1-M1	23.70	6.111	22.50		L1-M1	24.10	5.174	23.00
	L1-M2	24.90	4.433	26.00		L1-M2	26.70	4.644	26.00
	L1-M3	24.60	5.317	25.00		L1-M3	25.20	3.521	24.50
	L1-M4	25.70	3.713	26.00		L1-M4	28.40	3.273	29.00
	L1-M5	26.20	5.514	24.50		L1-M5	26.80	4.686	26.00
	L1-M6	25.60	3.026	25.00		L1-M6	29.10	3.695	30.00
	L2-M1	34.40	5.379	33.00		L2-M1	37.50	4.625	35.50
	L2-M2	37.10	6.506	36.50		L2-M2	34.30	4.473	35.50
	L2-M3	38.80	6.033	40.00		L2-M3	38.90	10.45	42.00
	L2-M4	41.10	7.109	41.00		L2-M4	33.60	8.909	32.00
	L2-M5	39.00	6.464	40.50		L2-M5	33.90	8.595	34.00
	L2-M6	40.30	3.773	41.50		L2-M6	34.80	7.208	35.50
	L3-M1	27.90	4.771	27.00		L3-M1	26.30	6.111	25.50
	L3-M2	30.60	6.041	31.50		L3-M2	24.90	4.433	26.00
	L3-M3	28.30	7.587	25.00		L3-M3	24.60	5.317	25.00
	L3-M4	29.80	5.884	30.00		L3-M4	25.70	3.713	26.00
	L3-M5	27.10	6.557	26.00		L3-M5	26.20	5.514	24.50
	L3-M6	29.20	5.473	28.50		L3-M6	25.60	3.026	25.00
	L4-M1	26.60	6.186	25.00		L4-M1	31.10	7.680	30.50
	L4-M2	25.70	5.851	25.50		L4-M2	30.20	7.146	29.00
	L4-M3	27.60	8.383	26.00		L4-M3	30.30	6.848	31.00
	L4-M4	25.70	6.273	24.00		L4-M4	31.80	7.254	33.50
	L4-M5	27.00	6.018	27.50		L4-M5	32.40	9.240	34.50
	L4-M6	27.50	6.932	24.50		L4-M6	30.90	8.621	32.00

L5-M1	31.20	4.131	32.00	L5-M1	28.20	6.125	25.50
L5-M2	29.10	7.141	29.50	L5-M2	26.50	3.951	25.00
L5-M3	27.70	4.111	28.50	L5-M3	27.80	6.374	25.50
L5-M4	27.70	6.447	28.50	L5-M4	25.90	4.175	24.00
L5-M5	27.80	5.574	26.50	L5-M5	27.20	2.781	27.00
L5-M6	26.40	6.915	27.50	L5-M6	28.90	4.458	29.50
L6-M1	27.00	3.916	27.50	L6-M1	29.30	7.150	33.00
L6-M2	25.90	5.446	26.00	L6-M2	26.70	6.601	27.00
L6-M3	27.10	5.724	25.50	L6-M3	27.00	4.000	26.00
L6-M4	28.70	8.920	28.50	L6-M4	27.40	6.786	28.00
L6-M5	27.70	4.084	28.00	L6-M5	26.20	5.493	26.00
L6-M6	28.70	5.813	30.00	L6-M6	24.80	5.287	25.50
L7-M1	23.70	6.993	22.50	L7-M1	25.90	5.043	25.00
L7-M2	22.70	7.528	24.00	L7-M2	26.70	5.293	24.50
L7-M3	19.70	7.617	18.50	L7-M3	26.30	3.831	25.00
L7-M4	21.50	5.836	23.00	L7-M4	26.10	6.773	24.50
L7-M5	23.70	5.794	24.50	L7-M5	26.00	4.830	26.00
L7-M6	24.20	3.824	23.00	L7-M6	26.20	6.088	26.00
L8-M1	28.90	5.109	28.50	L8-M1	24.70	4.001	23.00
L8-M2	26.10	4.202	24.50	L8-M2	25.70	2.669	25.00
L8-M3	23.80	2.150	24.00	L8-M3	27.90	4.254	27.00
L8-M4	26.30	4.572	25.50	L8-M4	28.40	5.854	26.50
L8-M5	28.60	4.402	30.00	L8-M5	29.60	8.669	32.00
L8-M6	28.10	4.932	27.00	L8-M6	29.00	5.292	30.00
L9-M1	26.90	4.306	25.50	L9-M1	24.00	2.944	23.00
L9-M2	27.20	5.712	24.50	L9-M2	25.90	6.297	27.50
L9-M3	26.20	6.989	25.50	L9-M3	26.30	4.644	25.50
L9-M4	25.80	5.224	25.00	L9-M4	28.30	4.739	27.00
L9-M5	25.40	4.402	24.00	L9-M5	30.20	6.529	30.00
L9-M6	25.90	3.725	24.50	L9-M6	31.60	6.114	33.00

L10-M1	26.50	4.950	27.50	L10-M1	23.70	5.697	23.00
L10-M2	26.40	3.836	26.00	L10-M2	25.60	3.978	26.50
L10-M3	25.30	3.889	24.00	L10-M3	26.00	6.018	26.50
L10-M4	27.00	7.333	27.50	L10-M4	27.40	5.125	26.00
L10-M5	26.00	7.717	26.00	L10-M5	24.80	3.521	23.50
L10-M6	25.50	7.792	23.00	L10-M6	26.20	3.048	25.50

Table showing specifications of microphones used in the study

Table 12

Specifications of microphones used in the study

Type	Sensitivity	Frequency Response	Dynamic Range
Benchmark	50 mv/pa (-26dBV)	6.3 Hz to 20 kHz	14.6 dB – 146 dB
M1 of L1	-52 dBV	200 Hz to 14 kHz	Not specified
M1 of L2	-56 dBV	300 Hz to 12 kHz	Not specified
M1 of L3	-62 dBV	200 Hz to 12 kHz	Not specified
M1 of L4	-60 dBV	300 Hz to 12 kHz	Not specified
M1 of L5	-62 dBV	300 Hz to 12 kHz	Not specified
M1 of L6	-62 dBV	300 Hz to 12 kHz	Not specified
M1 of L7	-56 dBV	300 Hz to 12 kHz	Not specified
M1 of L8	-60 dBV	300 Hz to 12 kHz	Not specified
M1 of L9	-62 dBV	300 Hz to 12 kHz	Not specified
M1 of L10	-52 dBV	100 Hz to 14 kHz	Not specified
M2	8 mv/pa (-42 dBV)	300 Hz to 18 kHz	Not specified
M3	-37 dBV	200 Hz to 18 kHz	Not specified
M4	-48 dBV	300 Hz to 15 kHz	Not specified
M5	-48 dBV	300 Hz to 15 kHz	Not specified
M6	-48 dBV	100 Hz to 18 kHz	Not specified